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LOBECTOMY FOR PULMONARY TUBERCULOSIS

COLONEL EDWARD D. CHURCHILL, M.C., A. U. S.

AND

ROBERT KLOPSTOCK, M.D.

BOSTON, MASS.

FROM THE HARVARD MEDICAL SCHOOL, AND THE SURGICAL SERVICES OF THE MASSACHUSETTS GENERAL HOSPITAL, BOSTON, MASS.

"RESECTION OF LUNG TISSUE is very hazardous in the presence of a positive sputum. If possible collapse therapy is preferred." This is the conclusion drawn from a compilation of the recorded cases of pulmonary resection for tuberculosis by recent authors.[3] In as rapidly developing a field as thoracic surgery, impressions drawn from past experience are notoriously misleading. This is particularly true if a reportorial account of experience is taken at its face value, without critical analysis.

The assembled cases of tuberculosis in which pulmonary resection has been carried out form an exceedingly heterogeneous group. Of 80 cases recorded as having been subjected to pneumonectomy or lobectomy, 30 came to operation with an erroneous diagnosis. This can only mean that the preoperative estimate of the situation and, consequently, the time of operation and the technics employed were not in terms of the pathology of tuberculosis. These operations were not performed "for" tuberculosis —the true nature of the disease was discovered too late for the observance of important elementary principles.

Twelve other cases were operated upon after collapse therapy had failed—always an added technical burden. Other cases were resected because of bronchiectasis, intractable hemorrhage, or in the presence of the fever and toxicity of bronchial strictures.

In the lobectomy group no reference to the surgical technics employed is made. Kent and Blades[2] conclude from their anatomic dissections that the application of individual ligation technic to the right upper lobe is possible, but appear to know of only one instance in which lobectomy has been thus performed. These authors state that as far as the left upper lobe is concerned, "except under unusually favorable circumstances, the individual ligation technic for resection will be hazardous or impossible."

Resections of upper lobes, both right and left, by individual ligation

technics have been routinely performed in this hospital since 1936, and total 21 in number.

While it seems unlikely that the opinions of Kent and Blades reflect a general belief, they at least suggest that a considerable number of the lobectomies for tuberculosis collected by Thornton and Adams[3] may have been carried out by the tourniquet technic. This is a procedure eminently successful in bronchiectasis but if applied to a tuberculous lesion would seem predestined to invite empyema, bronchial fistula, or both.

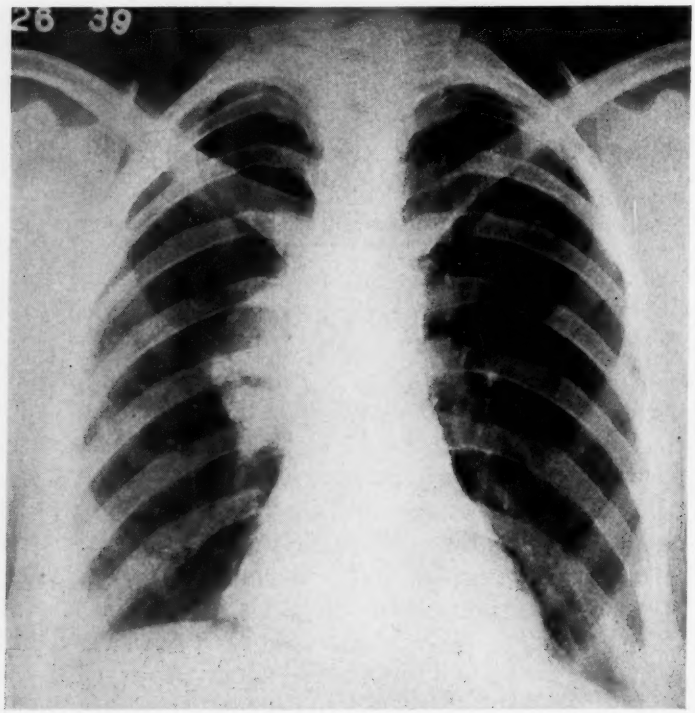

FIG. 1a.—Preoperative, May, 1939. Oval shadow of increased density in the apex of the right lower lobe. An irregular cavity present in the mass.

Not content to accept a conclusion based on the disasters and prejudices of the past, it seems desirable to present new evidence regarding what may be accomplished at the present time. The cases herewith reported are successive* lobectomies performed for pulmonary tuberculosis. All had positive sputum. All were operated upon with a preoperative diagnosis of tuberculosis.

Discussion of total pneumonectomy in tuberculosis is intentionally omitted, despite a relatively large and favorable personal experience with this pro-

* One other case in which lower lobectomy was performed for bronchial stenosis following upper thoracoplasty has been intentionally omitted, although the patient is alive and well, with complete healing. The case illustrates different surgical principles. Grouping dissimilar cases creates the illusion of impressive numbers, but obscures important principles from which conclusions may be drawn.

cedure. It is quite another topic. The principles that introduce total pneumonectomy into the treatment of tuberculosis are totally different from those that underlie lobectomy. At the present time, total pneumonectomy cannot be considered an alternative to collapse therapy *provided that collapse*

FIG. 1b.—Section of the resected right lower lobe. Well encapsulated caseous mass. No bronchial communication demonstrable.

therapy is applicable to the case under consideration. It is both irreversible and nonselective. It irrevocably and seriously limits any therapeutic procedure that may be needed for the lung of the contralateral side. Circumscribed by strict indications, total pneumonectomy in tuberculosis may be a life-saving operation when no other procedure is feasible.

Lobectomy, on the other hand, is proposed as a *highly selective measure* for dealing with certain unilobar lesions. It is, indeed, far more conservative

of pulmonary function than even a seven rib thoracoplasty. Whether or no it is more selective than a skilfully controlled artificial pneumothorax is open to debate. Properly used, artificial pneumothorax has the advantage of being a reversible form of therapy. The therapeutic goal is a re-expanded healed lung. As lobectomy is by definition irreversible, it can be suggested as an alternate to artificial pneumothorax only when tuber-

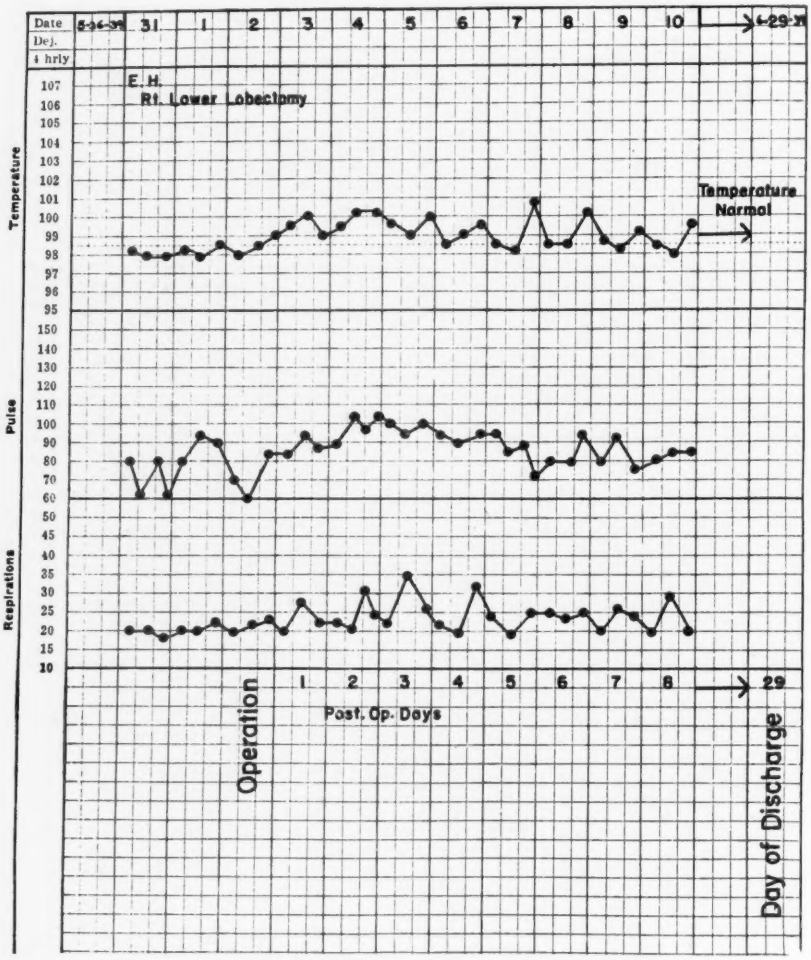

FIG. 1c.—Postoperative chart.

culosis has produced *irreversible* or *irreparable* destruction of lung substance. In these instances the strategy of a temporary reversible measure such as artificial pneumothorax is lost in the dilemma of either maintaining the collapse indefinitely, or facing reactivation by withdrawal.

The first three case records stand as instances of indications for lobectomy that can hardly be challenged as a departure from accepted surgical and

pathologic reasoning. Cases 4, 5 and 6, however, carry the matter further. Here, orthodox indications for thoracoplasty were disregarded, and a deliberate election of lobectomy substituted. Operation having been successful, it must be granted that *in these individual patients* lobectomy was preferable to thoracoplasty. The only question remaining is how frequently can such satisfactory results be achieved in a series large enough to be statistically significant. This can only be answered by further experience.

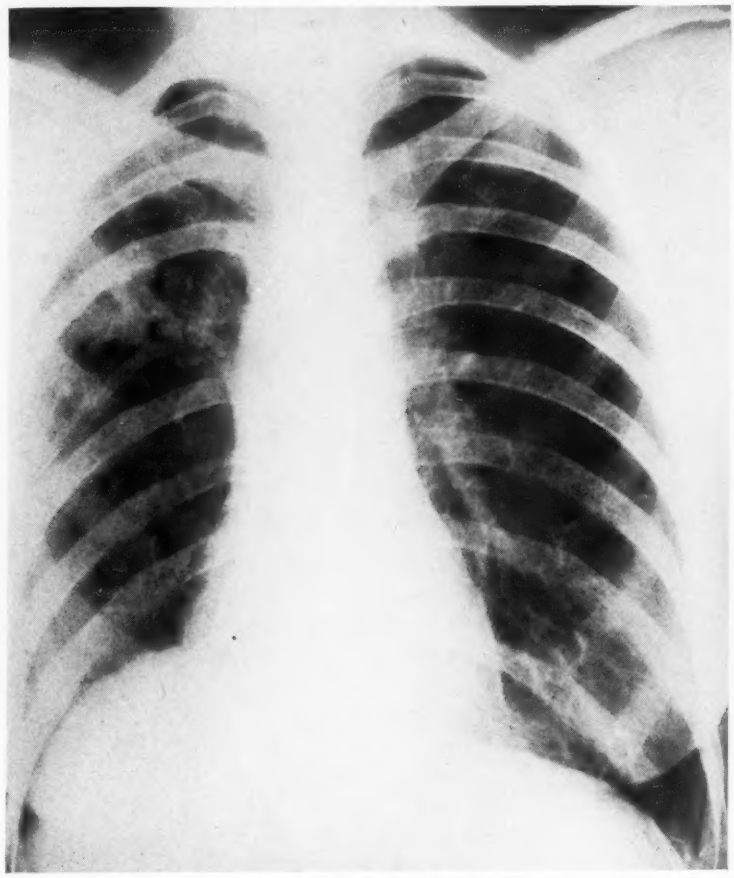

FIG. 1d.—Three years postoperative. The shadow beneath the 5th rib is not intrapulmonary but an opacity in the posterior pleura, continuous with the regenerated rib.

CASE REPORTS

Case 1.—U No. 194756: E. H., female, age 38 when she entered the Massachusetts General Hospital in May, 1939. She reported a run-down condition of 10 to 15 years' duration with increased susceptibility to respiratory infections. A "cold" in January, 1938, left a persistent cough. Roentgenograms and physical examination of the chest revealed an infiltration in the apex of the right lower lobe. *Sputum was positive for tuberculosis* in March, 1938. She entered a Saranac Lake sanatorium, where the sputum became "negative" in August, 1938, and remained so. The recovery seemed very satisfactory, although the area of density in the right hilum gradually increased

in size and showed a cavity in the center. Bronchoscopy and the bronchogram were uninformative. Several physicians considered that the appearance of the lesion was atypical for tuberculosis. Both malignancy and chronic lung abscess were considered.

On entry to this hospital the patient was essentially free of symptoms, her sputum was minimal in amount, and negative. The roentgenologist described an oval mass in the apex of the right lower lobe in contact with 6th and 7th dorsal vertebrae, measuring 6.5 x 4.5 cm. in diameter. An irregular cavity, with possible fluid level, was present in the mass. The periphery of the mass was smooth. There was definite thickening of the pleura overlying the vertebrae. The left lung was clear. The findings were considered consistent with tuberculosis, although admittedly unusual (Fig. 1a).

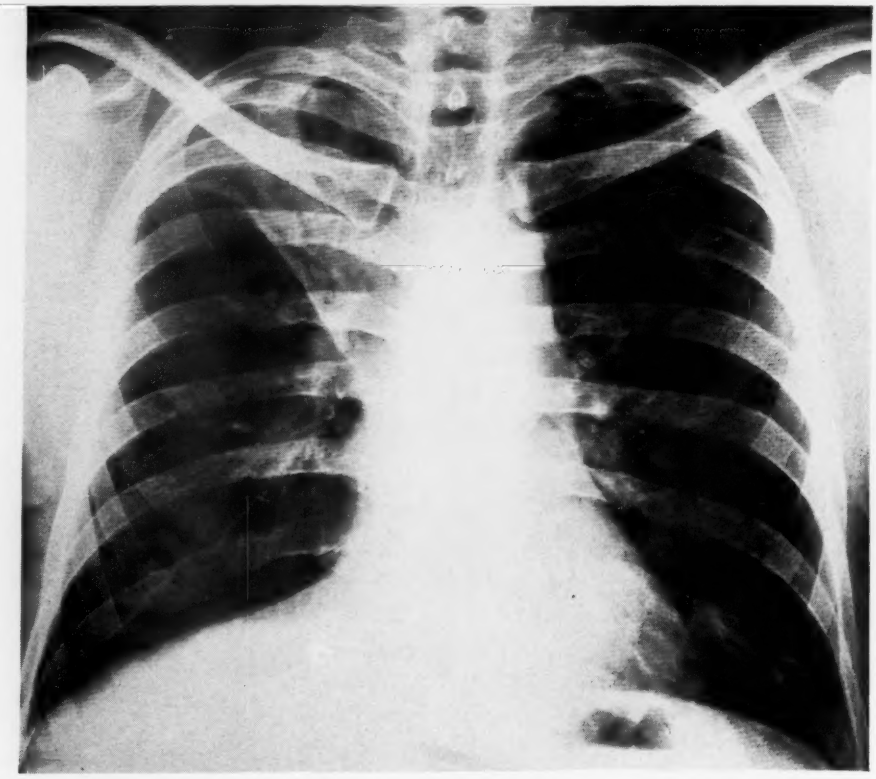

FIG. 2a.—Preoperative, November, 1941: Partially collapsed right upper lobe.

Operation.—6-2-39: Resection of the right lower lobe, with individual ligation technic.

Pathologic Examination.—In the apex of the right lower lobe was a caseous mass, well encapsulated, containing an irregular cavity (Fig. 1b). No free bronchial communication. A few scattered foci, pleural and subpleural, were present. *Smear from caseous material was loaded with acid-fast bacilli.*

Postoperative Course.—Uneventful. Patient was discharged on the 29th postoperative day in good health (Fig. 1c). She has been well since.

Postoperative Roentgenologic Examination.—June, 1942, three years after operation, negative for tuberculosis. Pleural scar in region of the 2nd rib (Fig. 1d).

COMMENT: This case represents the well known problem of the hilar round shadow, with or without cavitation. The majority of these are

found in the apex of the lower lobe. The "hilar" tuberculous lesion is the stepchild of surgical collapse therapy; disappointing results are likely to be obtained with any or all forms of treatment. Single foci in this location are usually hematogenous in origin without further tuberculous changes in the lung except for discrete, subpleural seeding in the same lobe. The latter

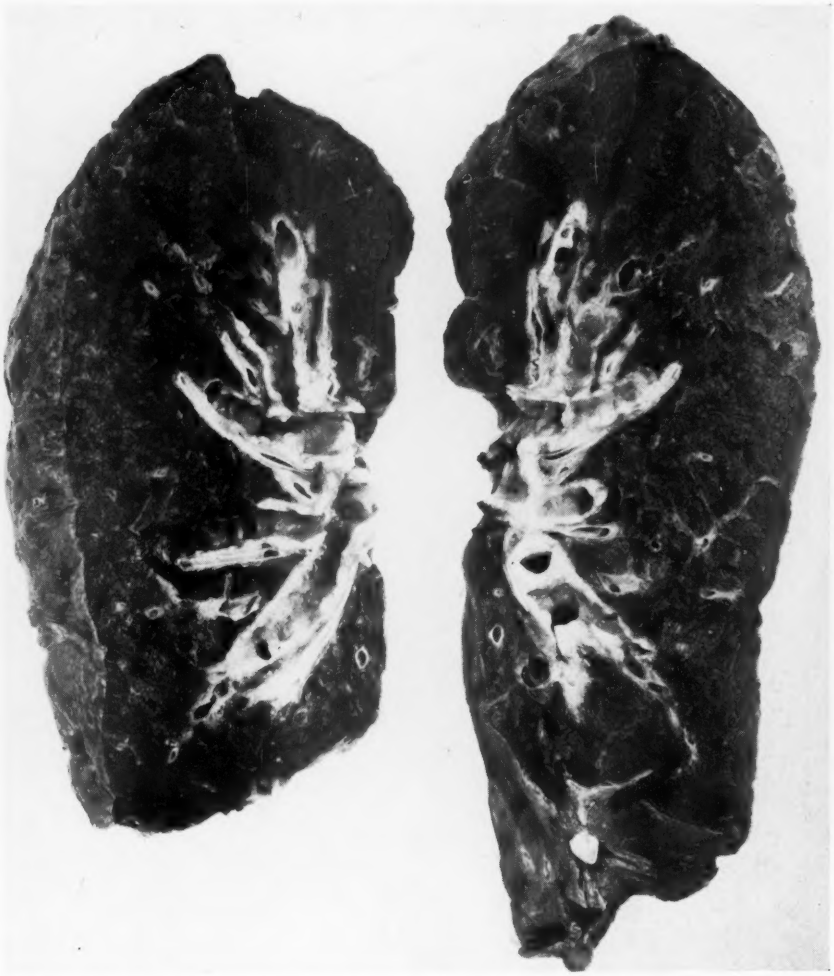

FIG. 2b.—Surgical specimen. The bronchi show a coarsely granular mucosal surface, particularly evident in the axillary branch. Microscopic changes throughout.

is a characteristic part of the pathologic pattern designated as "hematogenous." Massive foci are either the rather common "early round infiltration" with liquefaction that progresses slowly, or the so-called "punched-out" cavities, which are likely to be blocked and converted into a single caseous round focus. They closely resemble tumors, and are occasionally mistaken for lung abscesses. The findings in the present case are consistent with an early round infiltration in the state of protracted liquefaction.

Case 2.—U No. 329952: A. P., male, age 38, was admitted to the Massachusetts General Hospital in November, 1941. His previous history revealed that one and one-half years before entry, on a routine roentgenologic examination, a dense and contracted right upper lobe was found. Both sputum and gastric contents were *positive* for tuberculosis. At the Sanatorium of the Metropolitan Life Insurance Co., the patient was treated by bed-rest. A bronchoscopy revealed obstruction of the right upper lobe bronchus by a lesion described as a tuberculous granuloma. The condition of the patient remained satisfactory but the roentgenologic findings did not change. The minimal

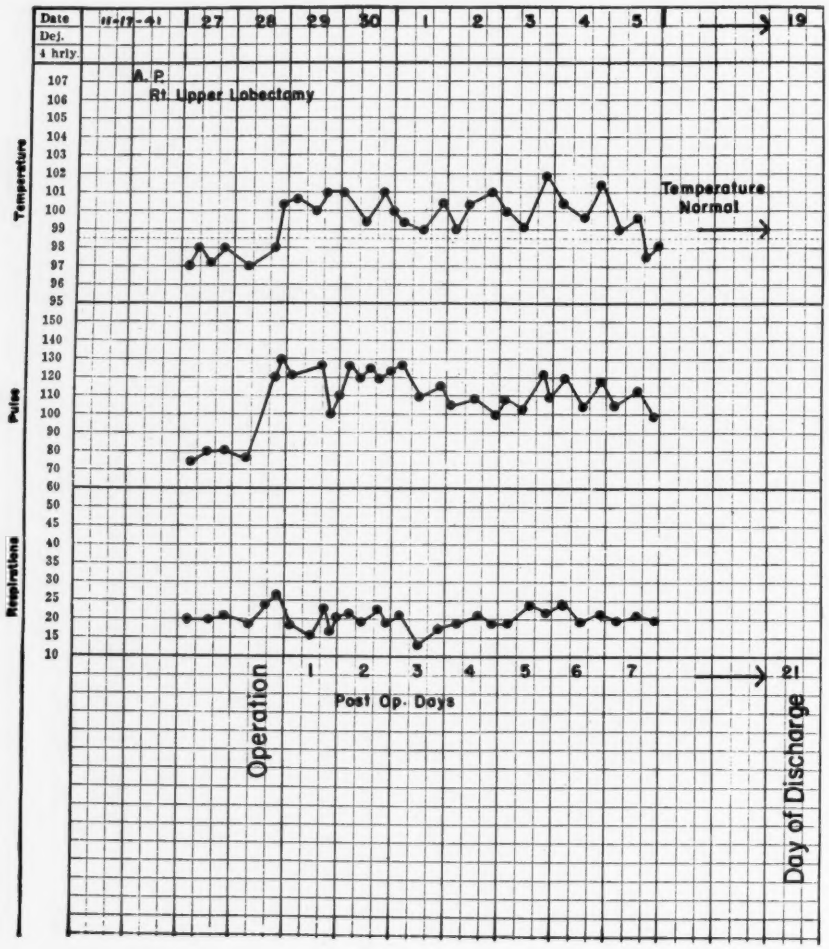

FIG. 2c.—Postoperative chart.

sputum continued to show tubercle bacilli. Surgery was advised, and the patient referred to the Massachusetts General Hospital. The physical examination, bronchoscopy and laboratory findings at this hospital confirmed the diagnosis of the Sanatorium. The interpretation of the chest film by our X-ray Department is as follows: "Partial collapse of the right upper lobe, with probable cavitation and stenosis of the right upper lobe bronchus" (Fig. 2a).

Operation.—11-28-41: Removal of the right upper lobe, with individual ligation technic.

Pathologic Examination.—Gross: A partially collapsed, anthracotic upper lobe, the pleural surface of which was smooth except for two small bands at the apex. Two major bronchi showed a coarsely granular mucosal surface, one a healed granuloma. There was no macroscopic parenchymal tuberculous lesion of any appreciable size. Those present were consistent with caseous bronchitis of the smaller and smallest bronchi. Scattered, grayish, small foci of fibrosis, some emphysema, numerous slightly dilated bronchi, some caseous, and some cystic in appearance made an impressive and characteristic pattern (Fig. 2b). *Microscopically,* studies revealed an almost uniform tuberculosis of the bronchial system of this lobe, although the tubercles were only to a moderate extent caseous, and subepithelial in location.

Postoperative Course.—Uneventful. The patient was discharged on the 21st postoperative day (Fig. 2c).

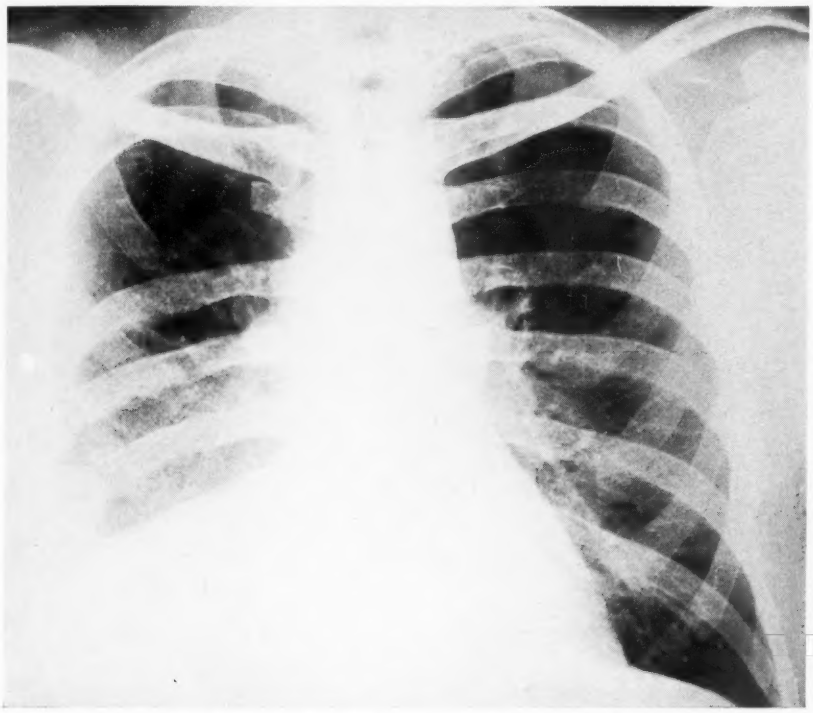

FIG. 2d.—Postoperative, ten months (May, 1942).

Postoperative Roentgenologic Examination.—May, 1942: Shows no pathology beyond usual potsoperative changes. Lower lobe completely reëxpanded. The elevation of the diaphragm is due to crushing of the phrenic nerve (Fig. 2d).

Case 3.—U No. 360821: H. P., female, age 32, mother of one child, entered the Massachusetts General Hospital from the Rutland State Sanatorium in June, 1942. The patient had been well until May, 1941, when she developed a "cold" which persisted as a severe chronic cough. She was fluoroscoped in June and a "bronchial trouble" diagnosed. In July, 1941, she was admitted to a Worcester, Massachusetts Hospital because of severe cough accompanied by fever of 103° F. There she was treated for pneumonia, according to the patient's report. After discharge from that hospital she went to a physician who found tubercle bacilli in her sputum. She was referred to the Rutland State Sanatorium and admitted there. On admission the chest film revealed a process in the right upper lobe, which appeared decreased in size. In

the basal third of the right upper lobe was an homogeneous density with sharp marginal demarcation towards the lower and middle lobe (Fig. 3a). The findings were considered consistent with tuberculous infiltration, although collapse was recognized as a part of the pathology. The suspected tuberculous involvement of the right upper lobe bronchus could no be confirmed at that time. Artificial pneumothorax on the right side was instituted and maintained (Fig. 3b). The patient's symptomatic recovery was good, she gained twenty pounds, but her sputum continued to contain tubercle bacilli.

Operation.—7-9-42: The right 4th rib was resected and the right chest was opened. The lung was found collapsed due to the previous pneumothorax. When positive

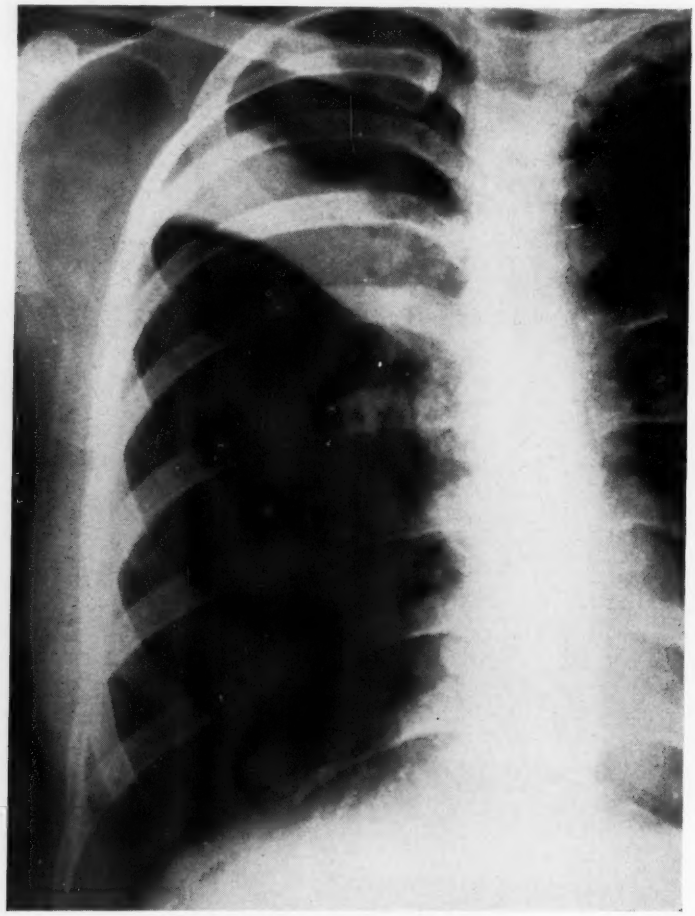

FIG. 3a.—On admission to the Rutland State Sanatorium, 1941. Right upper lobe decreased in size exhibiting an homogeneous density in the basal third.

pressure was applied the two lower lobes, *i.e.*, the middle and lower lobes, they expanded well but it was impossible to demonstrate any aeration of the upper lobe. A clamp was placed on the visceral pleura of the upper lobe to be used for traction purposes, and, from above downward, the lobe was dissected free from mediastinum and azygos vein where it was densely adherent. The structures at the hilum were isolated singly and the vessels doubly ligated. The lobe was then freed from the middle lobe. The ascending artery was identified and doubly ligated. The bronchus to the upper lobe was found to be partially stenosed by scar. The bronchus was closed. Denuded areas, particu-

larly over the azygos vein, were covered with pleura and the wound closed without drainage after the middle and lower lobes were expanded. Only a small amount of blood was lost during the entire procedure.

Pathologic Examination.—Gross: A Completely consolidated small right upper lobe. Upon section, the bronchi appear dilated and some of them coated with a thin caseous layer; others appear to be obliterated. No cavitation or scarring referable to previous excavation could be seen. In a small area there was a localized miliary caseation. This appeared, microscopically, as an interstitial seeding (Fig. 3c). *Microscopically*, the histologic appearance of the tuberculous lesions was exactly similar in character to that of the preceding case, although this lobe showed more extensive pathology. The lesions

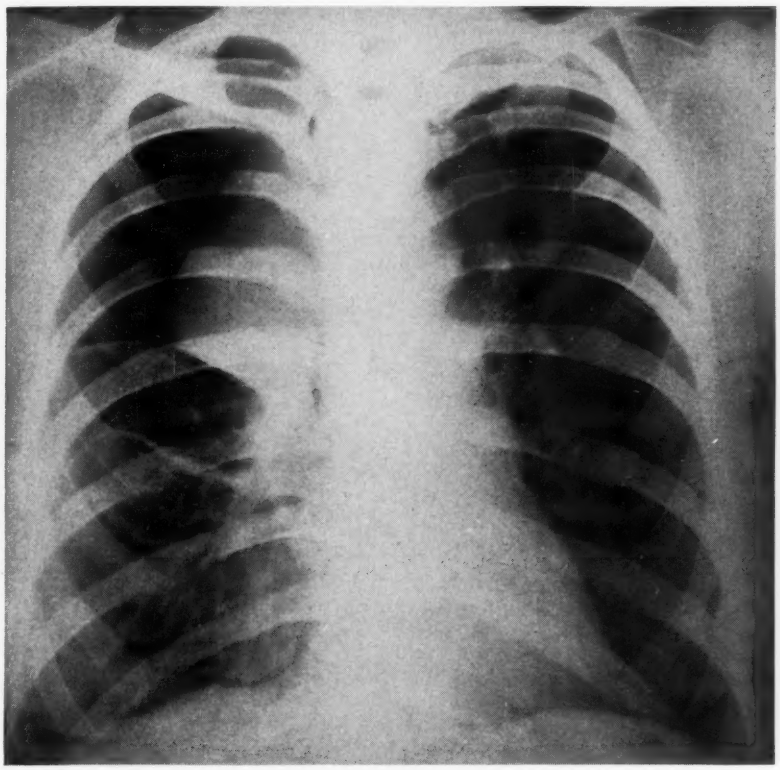

FIG. 3b.—Preoperative film. This roentgenogram is identical in appearance with one taken two days after the induction of artificial pneumothorax.

were confined to the bronchi and bronchioles. Large areas of fibrosis and atelectasis were present. At the base, posteriorly, a recrudescent Ghon focus could be seen. The hilum in the region of dissection was free of tuberculous nodes. The peribronchial lymph nodes contained small caseous foci.

Postoperative Course.—Uneventful. The patient was discharged on the 22nd day (Fig. 3d).

Postoperative Roentgenologic Examination.—Shows the condition August 3, 1942, four weeks after operation. Some apical fluid or apical thickening of the pleura is still present (Fig. 3e) although the Rutland State Sanatorium reported good breath sounds all over the chest at that time. On February 1, 1943, she is reported to be in perfect health, with fluoroscopic findings normal except for paralysis of the right diaphragm.

COMMENT: Cases 2 and 3 exhibit the peculiar pathologic pattern of unilobar tuberculous involvement of the bronchi, large and small. As to pathogenesis, an hematogenous origin is the most probable. Aspiration as the cause of this caseous bronchitis appears out of question, since there is no liquefying focus or chronic cavity to provide so thorough a seeding. Unilobar caseous bronchitis is likely to be erroneously considered as an infiltrative or exudative lesion due to the dense homogeneous roentgenologic appearance and sharp marginal demarcation. The third case (H.P.) demonstrates better than any statement the effect of collapse therapy upon a lobe the bronchi of which are diseased. The induction of the pneumothorax was followed by an immediate and complete collapse, giving in two days an appearance identical

FIG. 3c.—Surgical specimen. Cut surface of the resected lobe. See the note on the pathology of this specimen.

to the film reproduced in Figure 3b. Such an occurrence in the early phase of pneumothorax therapy should be regarded as an indication that one is not dealing with an infiltrative process which can be successfully treated by collapse therapy. This type of underlying pathology leads to the complication of the unexpandable lung. Even the most ideal and long standing collapse may not lead to healing of the tuberculous process if there has been an incorrect interpretation of the pathology. Thoracoplasty would have been equally ineffective. Ablation of the involved lobe seems the only feasible form of therapy.

Case 4.—U No. 345056: L. F., female, age 22, was admitted in March, 1942, from the Rutland State Sanatorium. Her disease was discovered in October, 1941, by a routine roentgenologic examination following a diagnosis of pulmonary tuberculosis made on her brother one month earlier. She was found to have an indurative tuberculosis, with cavitation in the right upper lobe, and positive sputum. She was admitted immediately to the Rutland State Sanatorium. Therapeutic pneumothorax could not be established because of obliteration of the pleural space, therefore, she was kept on bed-

rest for six months. On admission to the Massachusetts General Hospital the patient was in excellent condition. A roentgenogram showed mottled dullness in the right first interspace and the right apex. Within the mottling in the first interspace there was a cavity 2.5 cm. in diameter, lying in the posterolateral aspect of the lobe. This film showed essentially the same condition that had existed on admission to the Rutland State Sanatorium (Fig. 4a).

Operation.—4-27-42: Right upper lobectomy. Adherent and obliterated pleural space

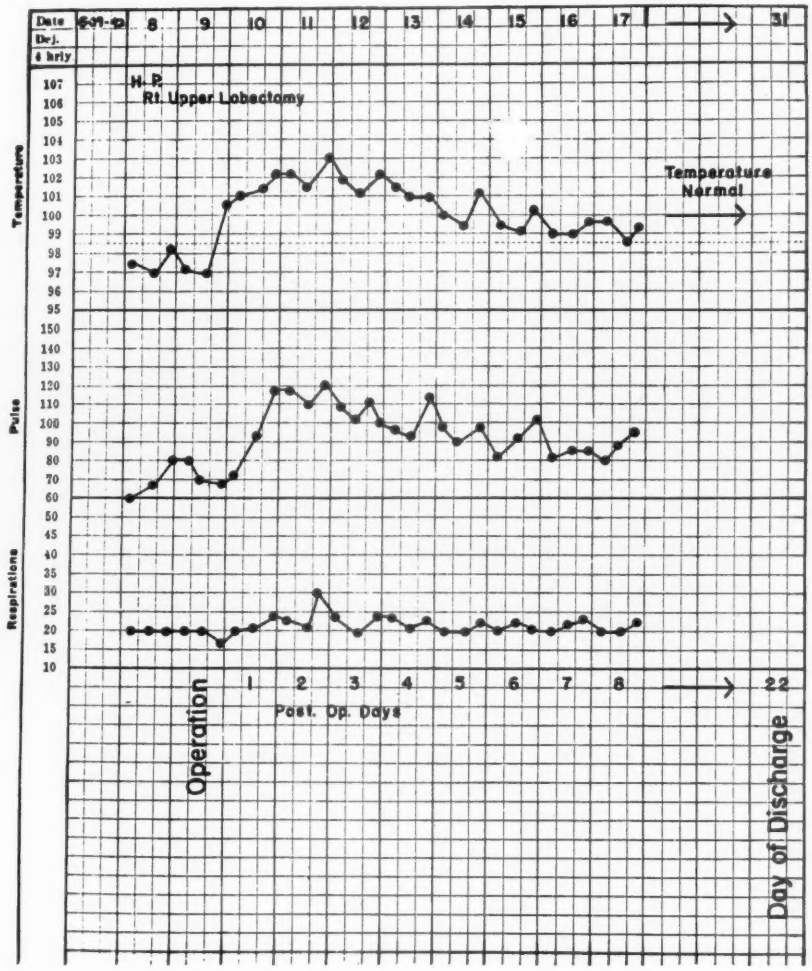

Fig. 3d.—Postoperative chart.

developed by resection of the 4th rib. Near the angle of the ribs in the lower portion of the upper lobe, the lung was densely adherent to the parietal pleura over the cavity. A patch of parietal pleura, approximately 3 cm. square, was excised to keep the plane of mobilization at a distance from the wall of the cavity.

The remainder of the parietal surface of the lobe was easily mobilized, although everywhere adherent. Considerable care was necessary in dividing the fissures, the one with the lower lobe being involved in the inflammatory reaction of the disease, and the anterior portion of the middle lobe fissure being anatomically very incomplete.

After these were developed the hilum was easy to dissect, ligating the superior branch of the pulmonary artery in two divisions and the superior pulmonary vein in three branches. No ascending upper lobe artery was identified. It was believed to be absent. The bronchus was isolated and secured with a catgut mattress suture. It was amputated at its first division and the end closed with interrupted silk after cauterizing the mucous membrane with phenol. No pedicle flap was available for coverage. The mediastinal pleura was sutured over it and, after crushing the phrenic nerve at the level of the azygos vein, the hilar portion of the lower and middle lobes could be drawn up to cover the bronchial stump.

The adhesions of the dorsal segment of the lower lobe to the parietal pleura were divided to allow its ascent toward the apex. The lower part of the pleural cavity was

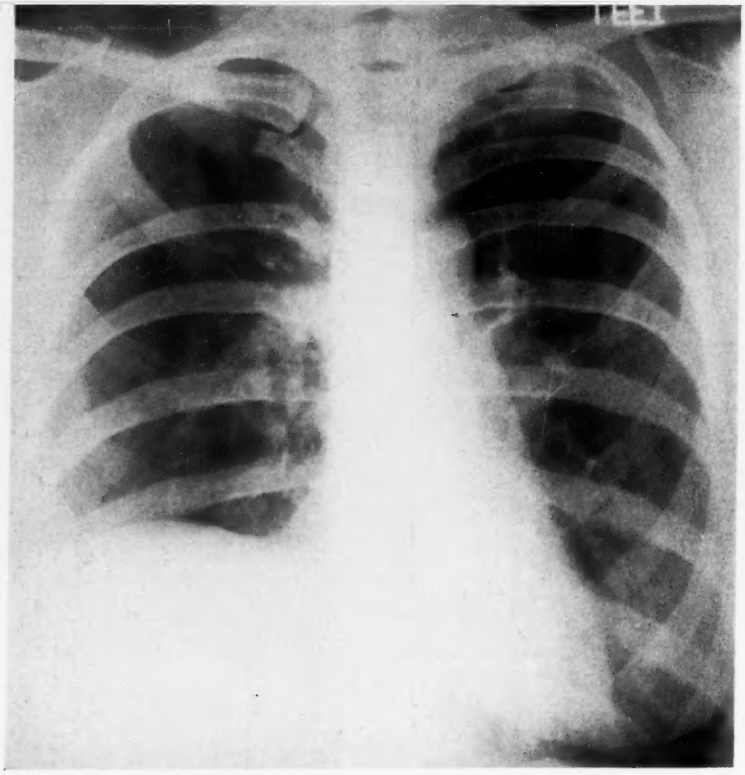

FIG. 3e.—Roentgenogram of the chest four weeks after operation (August 3, 1942). No tuberculous pathology visible.

found completely obliterated. The pleural space was dusted with four grams of sulfanilamide, and the incision closed with silk, without drainage. Air was aspirated.

Pathologic Examination.—Gross: The specimen shows the posterior part of the right apex changed by radiating induration of rubber-like consistency. At the center lies a "punched out" cavity the inner surface of which is coated with a very thin caseous exudate. A small bronchus, the only one, leading toward the cavity is obliterated. The superior and anterior part of the apex exhibits an irregular gray scar intermixed with emphysematous parenchyma representing a healed lesion of earlier date (Fig. 4b).

Postoperative Course.—This was, as in preceding cases, extremely smooth and uneventful. She was discharged on the 35th postoperative day (Fig. 4c). One month after operation tuberculin tests (1:50,000 and 1:20,000 O.T.) were negative. She is living with her family at home.

Postoperative Roentgenologic Examination.—July, 1942: Showed no pathology except usual postoperative changes (Fig. 4d).

COMMENT: This patient was deliberately chosen, with her consent, for lobectomy as preferable to a thoracoplasty. Artificial pneumothorax was impossible.

Case 5.—U No. 373702: E. S., female, age 22, was admitted to the Massachusetts General Hospital in September, 1942, from the Channing Home. She had entered the Channing Home in August, 1941, with a history of fatigue and cough of six months' duration. A roentgenogram of her chest at that time showed a cirrhotic process with large multiple cavitations in the right upper lobe and two small liquefied aspiration

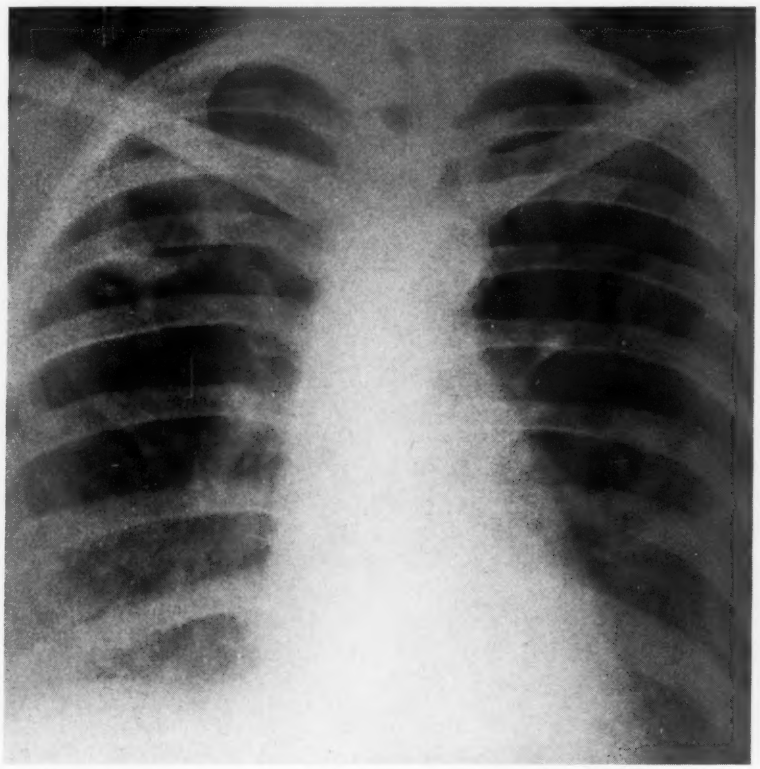

FIG. 4a.—Roentgenogram on admission to sanatorium, same as preoperative film, taken six months later. In the right first interspace mottled dullness with cavitation, 2.5 cm. in diameter.

foci in the left midlung field (Fig. 5a). Sputum was strongly positive. In September, 1941, a right pneumothorax was instituted but was abandoned shortly thereafter because of numerous adhesions. In December, 1941, a pneumothorax on the left side was started but discontinued because of gastric distress. In January, 1942, a right temporary phrenic paralysis was induced. She continued to improve in the Channing Home but in April, 1942, she had a small hemoptysis. Temperature reached a maximum of 99.4° F. The sputum remained strongly positive.

On admission to the Massachusetts General Hospital for surgery her general condition was good. A roentgenogram showed essentially the same process as at entry to the Channing Home. The right upper lobe was, in its larger portion, destroyed by cavitation. The remaining parenchyma of the lobe appeared dense.

The left lung was apparently stable but there was a suggestion of a one cm. cavity with some infiltration around it in the mid-lung field, where the cavitation had been demonstrated previously (Fig. 5b). The sputum was loaded with tubercle bacilli. Bronchoscopy was uninformative.

Operation: A right upper lobectomy was performed on September 16, 1942. Under intratracheal gas-oxygen-ether anesthesia, with the patient lying on her left side, the right chest was prepared with iodine and an incision made over the 5th rib. The muscles were divided down to the chest wall. Subperiosteal resection of the 5th rib was done. The pleural cavity was opened through an area free of adhesions, and it was then seen that the right upper lobe was densely bound down by adhesions. An

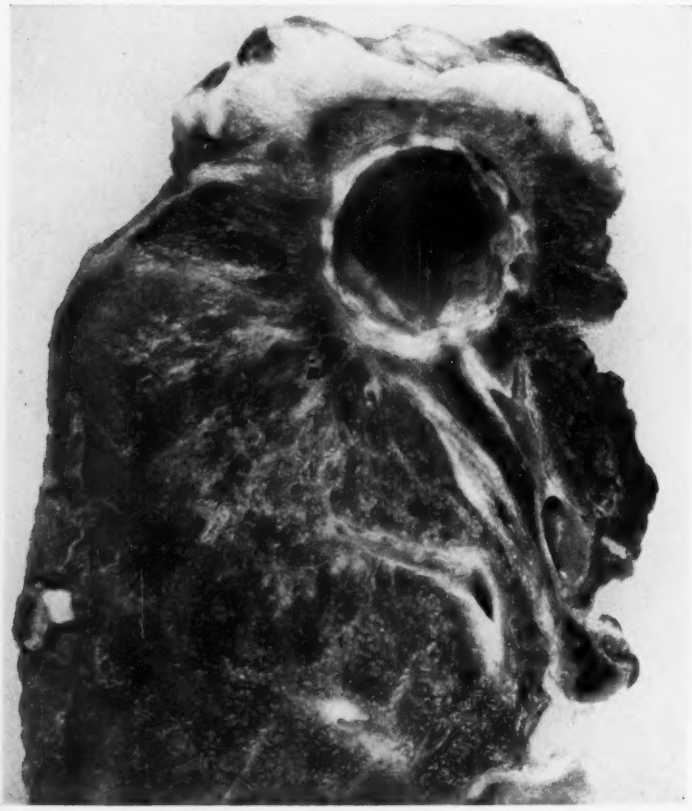

FIG. 4b.—Surgical specimen. The photograph shows only the diseased area. Note the sclerotic tissue surrounding the cavity.

intrapleural dissection was started and continued until it was found that bleeding was excessive in this plane. Extrapleural dissection was then attempted and found to be more feasible. By combined intra- and extrapleural dissection the upper lobe was entirely freed, bleeding vessels being controlled with dura clips and silk ligatures. The fissure between the middle and lower lobes of the lung was found to be free of adhesions. Following the individual ligation of the pulmonary veins and arteries, the bronchus was isolated, closed with a mattress suture, and cut across. Several sutures were placed to close the bronchus. During the entire procedure there was no contamination of the pleural space nor was the lung tissue opened. The middle lobe was freed so that the end of it could be sutured over the closed bronchus. Four grams of sulfanilamide were dusted into the pleural cavity after hemostasis was complete. The lower lobe was

entirely mobilized to make expansion of that portion of the lung more complete postoperatively. The chest was closed in layers with multiple interrupted silk sutures. The skin was closed with silk. No drainage.

Pathologic Examination.—A small sclerotic right upper lobe. It is almost completely excavated presenting a large cavity over an area 6 x 8 cm. The excavation extends immediately beneath the pleura and presents a rigid wall surrounded by firm

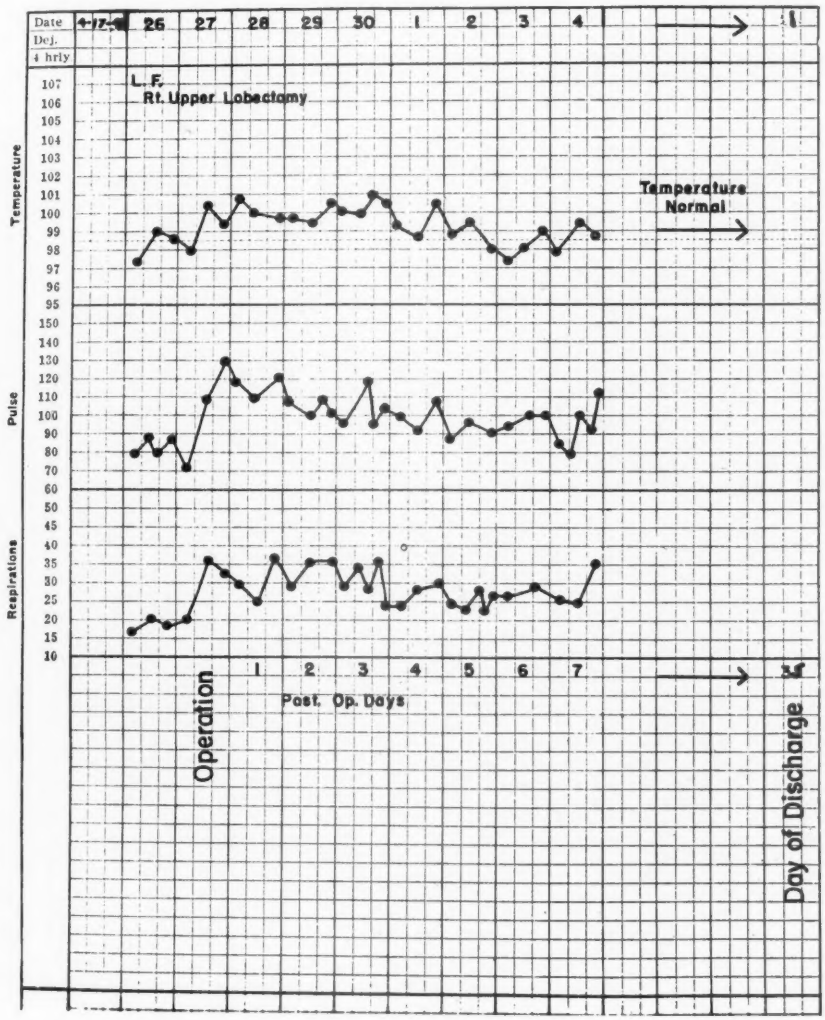

FIG. 4c.—Postoperative chart.

induration. The inner wall of the cavity is coated by a heavy caseous lining and affords only one small communication with the bronchial tree. The rest of the lobe is completely airless and does not show active tuberculous foci. At the very apex there is a layer of fibrous tissue representing extrapleural surgical resection (Fig. 5c).

Postoperative Course.—Uneventful. Patient had no cough and no expectoration whatsoever. Discharged on the 23rd day (Fig. 5d). Preoperative and postoperative tuberculin skin tests showed a sensitivity 1:50,000.

Postoperative Roentgenologic Examination.—December 11, 1942: Showed on the

right side no pathology, other than postoperative changes. The lesion on the left was resolved except for a 1.5 cm. thin wall ring shadow (Fig. 5e). Since the main lesion had been eradicated, the control of the contralateral cavity by pneumothorax became a hopeful therapeutic measure. Accordingly, on December 16, 1942, left pneumothorax was re-established and has been continued (Fig. 5f). In March, 1943, sputum was still positive, and bronchoscopic examination showed no evidence of ulceration or tuberculous granulation in any of the bronchi.

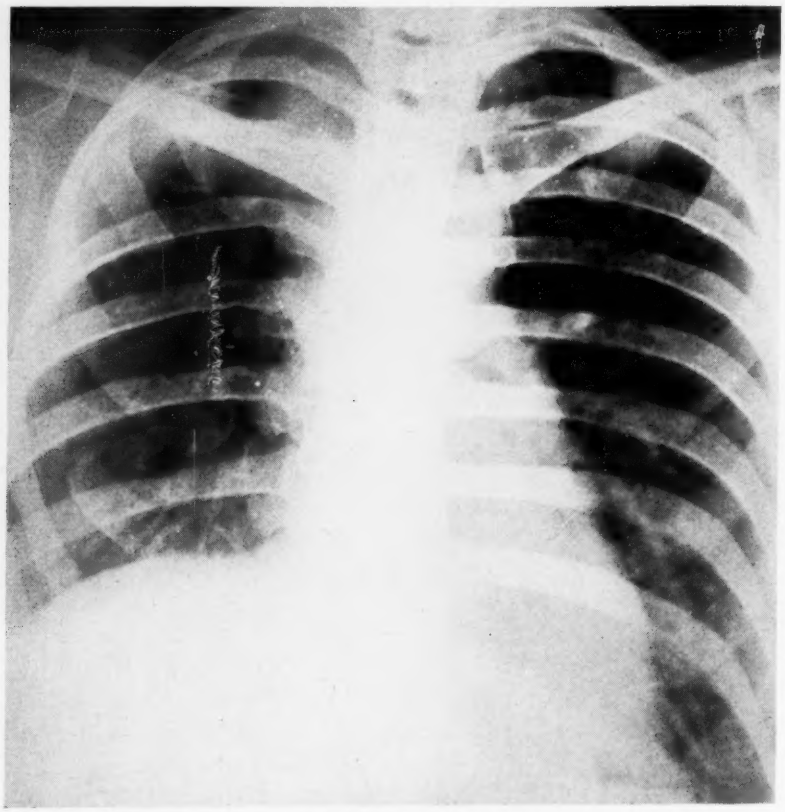

FIG. 4d.—Postoperative three months (July, 1942). No tuberculous pathology visible.

COMMENT: The case presents the rather crucial problem of contralateral disease in the presence of a giant upper lobe cavity in a young woman, age 24. The contralateral side had exhibited susceptibility to bronchogenic spread and contained two small cavities. Pneumothorax had proved to be ineffective. In accord with usual practice, thoracoplasty would be the method of treatment. Considering the extent of the disease, several stages would have been required to close this cavity and the tiny bronchial communication may well have produced the "block" phenomenon. During the entire course of the surgical program the dangers of bronchogenic aspiration spread would have persisted.

The selective nature of lobectomy is well illustrated in that the chief focus of the disease was eliminated by a single operative procedure that

FIG. 5a.

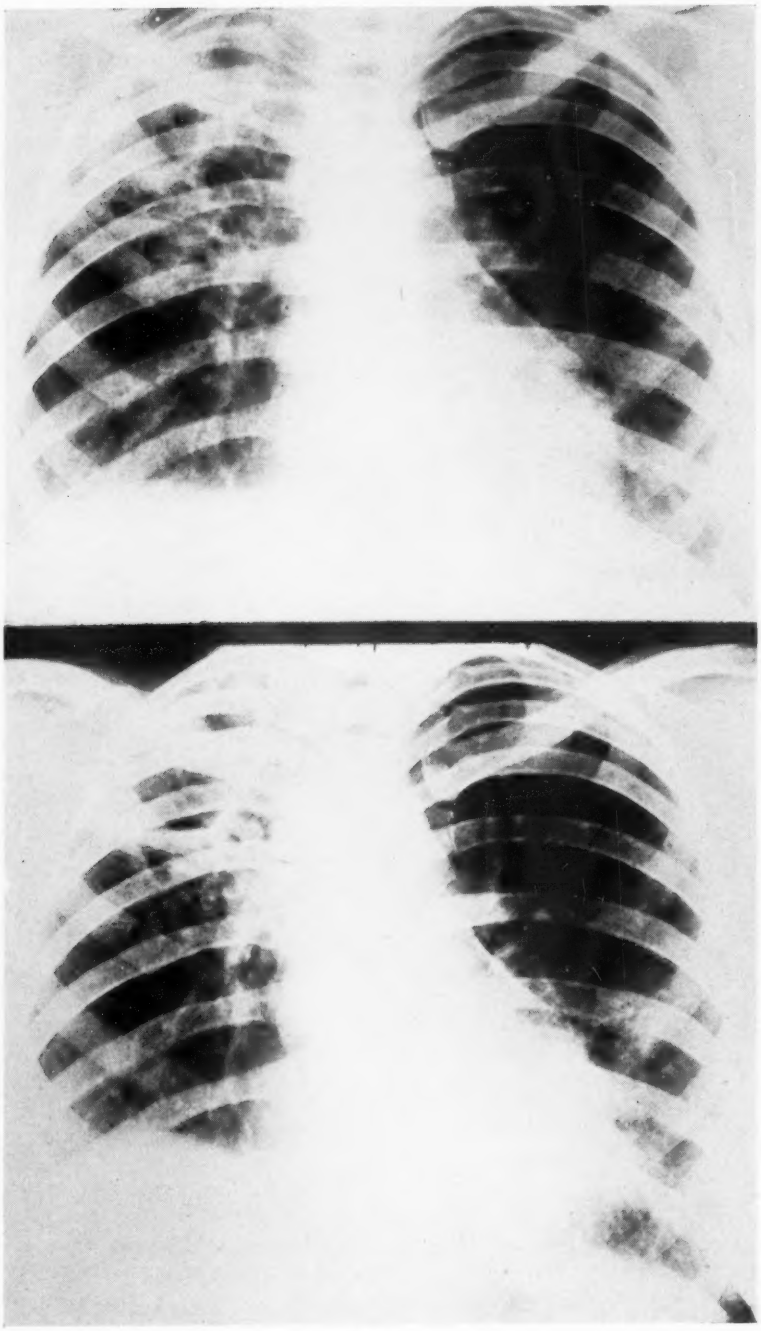

FIG. 5b.

FIG. 5a.—August, 1941. Cirrhotic tuberculosis, with extensive cavitation in the right upper lobe. Left midlung field shows two cavities, representing liquefied aspiration foci.

FIG. 5b.—On admission to the Massachusetts General Hospital. The cavities in the right upper lobe enlarged. Lesion on the left side unchanged but obscured by perifocal infiltration.

left the right lower and middle lobes intact. It was then possible to institute a contralateral artificial pneumothorax for the preexisting bronchogenic spread.

Case 6.—U No. 377199: M. M., female, age 35, was admitted in October, 1942, to the Massachusetts General Hospital. Her first breakdown was 13 years previously—treated with bed rest for two years. Sputum was negative at that time. In 1936, tuberculosis flared up in the left upper lobe. According to the available roentgenogram (Fig. 6a) she had a productive tuberculosis in the left upper lobe with a few circum-

FIG. 5c.—Surgical specimen. Note the size of the cavities, their sclerotic walls and the lack of bronchial drainage with the exception of a single "pin head"-size communication with the bronchial tree. There was no reason to predict that a "blocked" cavity existed.

scribed foci but without visible cavitation. The sputum became positive at that time. She was treated with artificial pneumothorax on the left side (Fig. 6b). The treatment was continued for three and one-half years. After reexpansion she was able to lead a normal and active life. In June, 1942, she developed a productive cough. The sputum became *positive* for tubercle bacilli. In July, 1942, she was concerned with marital worries and difficulties and lost 14 pounds of weight. A roentgenogram, however, did not show any change as compared with the one taken after her pneumothorax was discontinued. At that time she also complained of fatigue. She was readmitted to the Channing Home where the pneumothorax had been originally started. The staff of this institution referred the patient for surgery.

On admission to the Massachusetts General Hospital the patient was in good general

condition. The sputum was minimal but contained tubercle bacilli. A roentgenogram (Fig. 6c) showed a shrunken and dense upper lobe on the left side, with scattered, circumscribed foci, varying in size from 2 to 5 mm. in diameter. No cavity was visible.

Operation.—10-14-42: A left upper lobectomy was performed. With the patient under intratracheal gas-oxygen-ether anesthesia, and on her right side, the left chest was prepared with iodine. An incision was made over the course of the 5th rib and curved in order to free the tip of the scapula. The trapezius was divided posteriorly, then the rhomboids and serratus posticus identified. This was separated from its attachment to the 5th rib and suberiosteal resection of the rib carried out. The pleural cavity was entered. Dissection of the left upper lobe was then carried out through very tenuous, avascular adhesions. Sharp dissection was necessary throughout. The

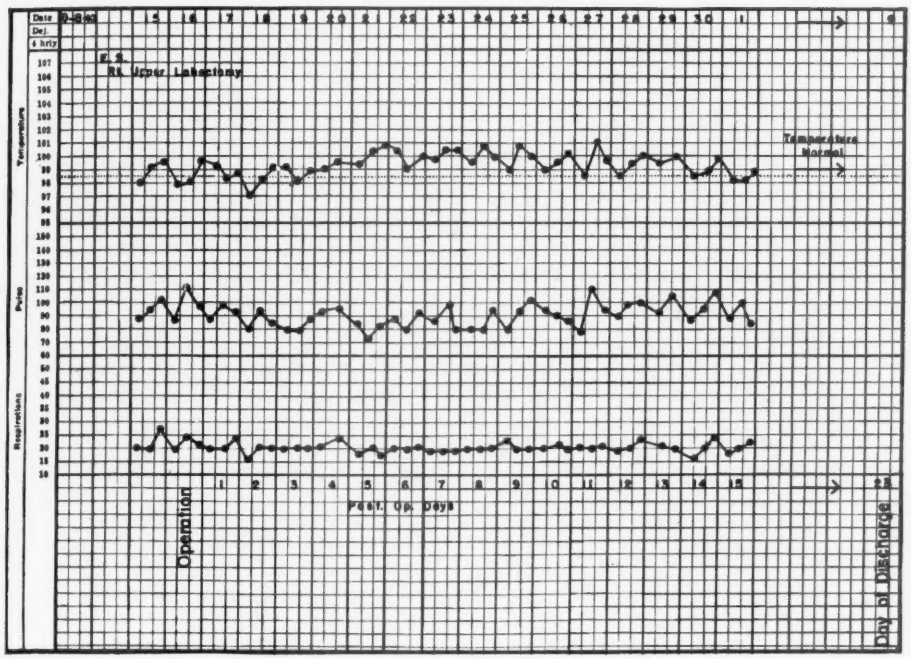

FIG. 5d.—Postoperative chart.

fissure between the lower and upper lobes of the left lung was identified and developed. On the posterior upper aspect of the lobe, considerable difficulty was met in freeing the lung from adhesions. The hilum of the lung was approached and individual ligation of the arteries and veins carried out. The fissure between the upper and lower lobes was then completed by cutting between clamps and suturing the defect. The bronchus to the left upper lobe was identified, two stay-sutures inserted and the bronchus divided. The bronchus was then closed with multiple interrupted silk sutures. The left lower lobe was then partially mobilized and a pedicle sutured over the closed bronchus. The specimen removed contained left upper lobe and lingula. Four grams of sulfanilamide were dusted into the pleural cavity, and the chest closed in layers, the divided muscles and skin being approximated with silk. The patient left the operating room in good condition, blood pressure being 110/80, and her blood well oxygenated.

Pathologic Examination.—Gross: (Fig. 6d): A shrunken left upper lobe. The pleural surface is roughened by the presence of fibrous tags representing old adhesions. The major bronchi have thickened walls and narrowed lumens. At the very apex there are several foci which hold inspissated caseou débris, and have sharply defined walls. They represent either previous cavities or old round foci, the latter are the

FIG. 5e.

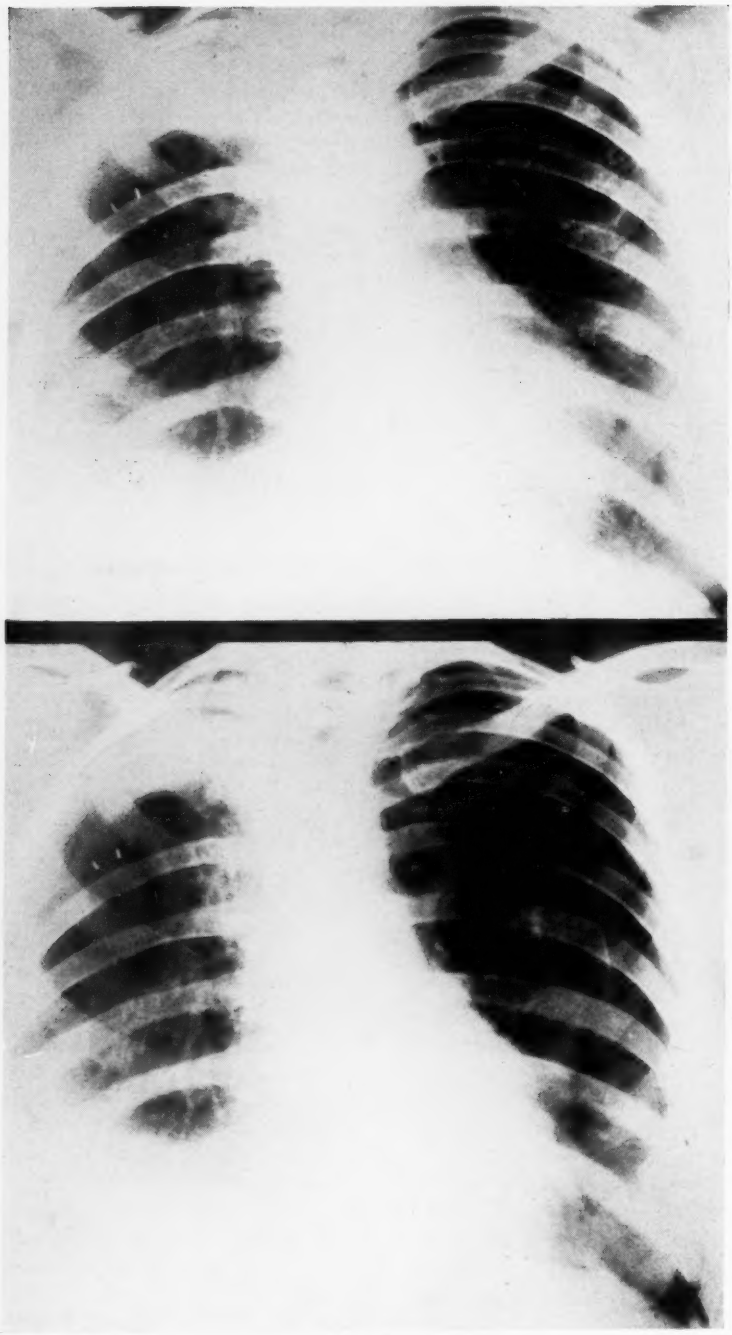

FIG. 5f.

FIG. 5e. (Above)—Postoperative eight weeks (December 11, 1942): The right side is without visible tuberculous pathology. The left side exhibits two thin-walled small cavities, without the perifocal infiltration seen in the immediately preoperative film. No signs of postoperative exacerbation.

FIG. 5f. (Below)—Postoperative roentgenogram (December 30, 1942): Marginal artificial pneumothorax induced on left. Cavities no longer visible.

more probable. In the midportion of the lobe a few more foci are seen, the contents of which are caseous and firm. These, too, are well encapsulated but one presents a possible caseous breaking within the capsule. At the base of the lobe linear caseous stripes are seen representing traces of caseous bronchitis. The upper part of the lobe contains considerable fibrosis; the lower part is partially atelectatic. Both the distribution and the morphology of the caseous foci and the clinical course suggest very strongly an hematogenous origin of the process.

Postoperative Course.—Postoperative course was uneventful except that the patient

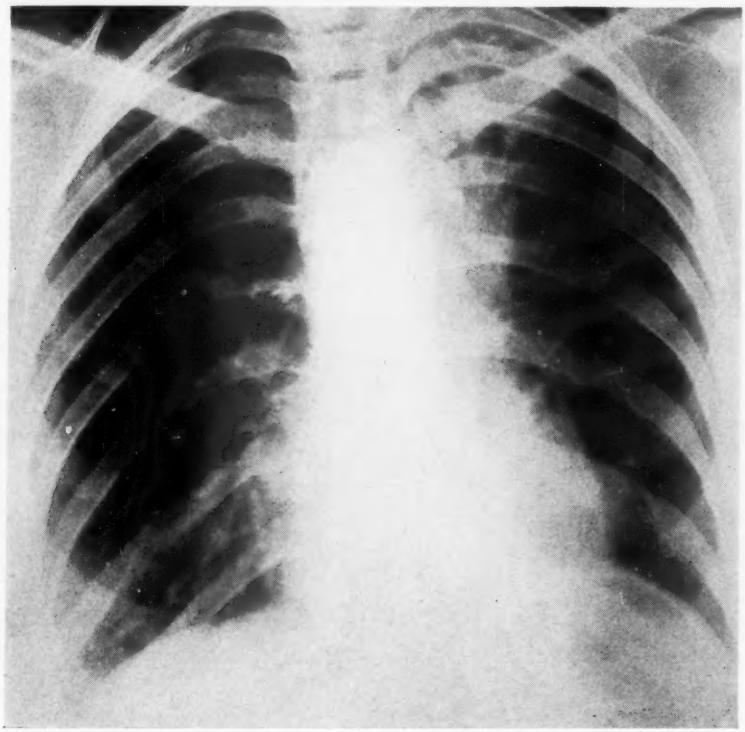

FIG. 6a.—May, 1936: Productive well circumscribed foci, no visible cavitation. Sputum positive for tuberculosis. Pneumothorax induced.

developed a transient pleural effusion which resorbed again within a few weeks. Patient was discharged on the 30th postoperative day to the Channing Home (Fig. 6e).

Postoperative Roentgenologic Examination.—1-15-43: Showed a completely re-expanded left lower lobe, with a probable small effusion in the apex of the pleural space (Fig. 6f). Although the patient's general condition is good, her sputum has remained positive. Bronchoscopic examination on March 12, 1943, revealed narrowing and irregular proliferation of the left main bronchus with a 5 mm. ulceration.

COMMENT: The clinical significance of this case resides in the problem of cavity healing. Considering the complexity of questions and factors involved, the problem is proposed rather than discussed at this time. Cavity healing has been studied in recent years by Auerbach, Pagel, Pinner and others. According to these studies three anatomic forms of healed cavities can be differentiated: 1. The solid focus due to retention, inspissation, and final calcification of the cavity contents. 2. Radiating scar. 3. The bron-

chiectatic area remaining after the substitution of caseous and tuberculous elements in the cavity wall by ordinary granulation tissue, with subsequent epithelization and fibrous shrinking of the space. Healing by conversion of the cavity into a solid focus seems to be the most frequent form of cavity healing. It is noteworthy that the cases studied, the number of which is too small (16) to permit of a statistical analysis, were almost without exception obtained from individuals previously treated with some form of collapse therapy. In other words, collapse therapy, pneumothorax and thoracoplasty

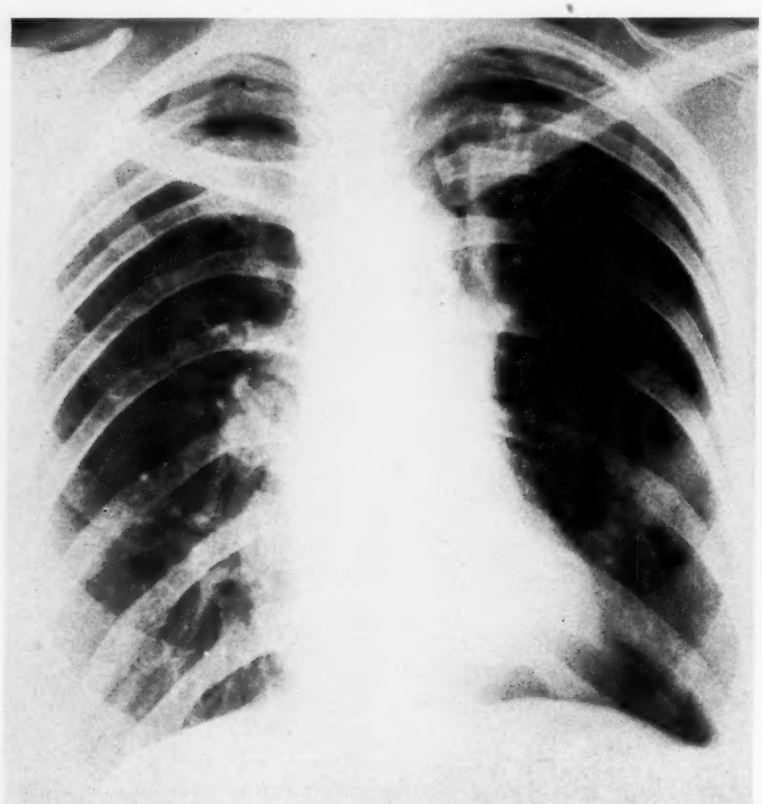

FIG. 6b.—August, 1936: Incomplete artificial pneumothorax.

alike, may favor the conversion of the open cavity into a closed one that may still maintain a caseous focus.

We have been fortunate in being able to carry on careful studies on a relatively large number of surgically removed lobes and lungs. The specimens have all shown one type of cavity residuum, the so-called converted focus which, in clinical practice, is designated as "healed." These well walled-off foci, although firm in consistence, invariably contain caseous material. One or two in each specimen appear to be in the process of breaking through their capsules. It does not appear to be a permanent and safe method of cavity healing, yet it may well represent the characteristic response to collapse therapy.

The reliable type of cavity healing seems to be the concentric shrinking, with scarring. The two other types represent unrepaired damage to the lung, with a constant potentiality of reactivation or spread. These observations help explain the reluctance of the clinician to permit reexpansion of the lung after the disease appears to be under control with artificial pneumothorax. They also add weight to the proposal that irreparably damaged lobes be resected.

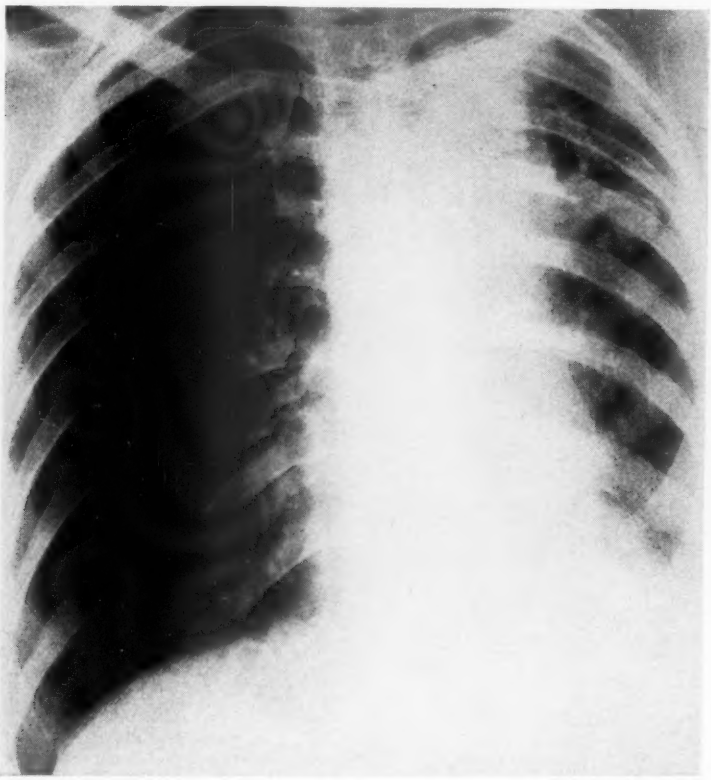

FIG. 6c.—Preoperative. The process present in the left upper lobe essentially unchanged compared with postpneumothorax roentgenograms, and with that from 1936.

TECHNICAL NOTES

Bronchoscopy: All patients were subjected to bronchoscopy preoperatively to rule out the presence of active ulceration in the trachea or stem bronchus.

Anesthesia: Gas-oxygen-ether administered through an intratracheal tube.

Incision: Posterolateral, with resection of a single rib at the appropriate level. An anteriorly placed incision would seem to impose unnecessary technical difficulties on the operator.

Dissection: In areas overlying densely adherent cavities the dissection is transferred from the intrapleural plane to the extrapleural plane. In looking for a fissure, however, one must be certain to return to the intrapleural plane. A layer of thickened parietal pleura will completely obscure the fissure. Meticulous hemostasis is maintained by ligatures and silver clips.

The frequently repeated statement that access to the hilum may be blocked by tuberculous infiltration of lymph nodes is erroneous. Once the primary lesion is established, tuberculous foci in an organ do not produce a lesion in the corresponding lymph nodes.[1] Upper (or lower) lobe lobectomy is carried out by individual ligation technic. An accurate knowledge of the complex anatomic structures and their common variations is essential.

FIG. 6d.—Surgical specimen. Note the morphology and distribution of the foci. Traces of caseous bronchitis. (Pattern of hematogenous pulmonary tuberculosis.)

Following upper lobe resection the lower lobe, if adherent, is mobilized so that it may ascend to fill the apex. Intrathoracic crushing of the phrenic nerve has been done to reduce temporarily the volume of the hemithorax. Whether this is necessary or even advisable remains to be seen. In thoracoplasty one fears lower lobe aspiration pneumonitis in the presence of a paralyzed diaphragm. With surgical ablation of the source of sputum and complete freedom from paradoxical motion of the chest wall the conditions are quite different.

Silk technic is used throughout except for a proximal row of sutures penetrating the bronchial mucosa, where fine chromic catgut has been employed.

The pleural cavity is closed without drainage and the chest wall muscles approximated by interrupted sutures of fine silk. Intrapleural pressure is adjusted to a moderate degree of negative pressure.

Postoperative Care: An oxygen tent is used routinely for the first 24

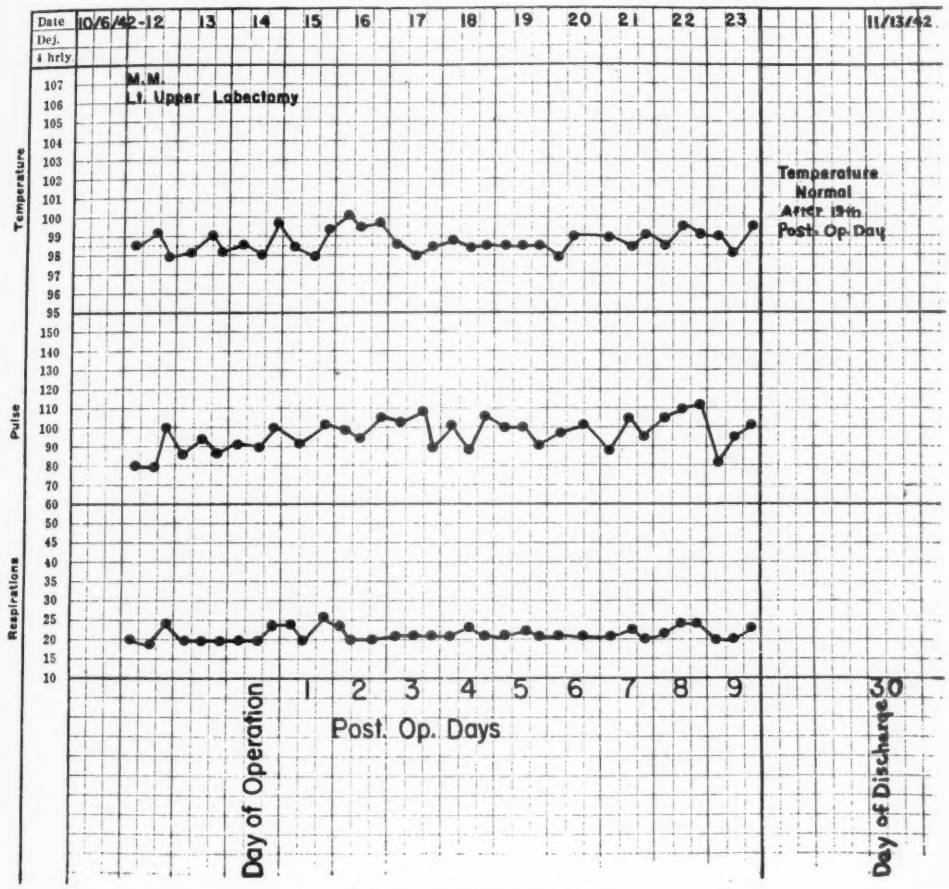

FIG. 6e.—Postoperative chart.

hours. Fluid or residual air may be reduced with needle aspiration, according to individual indications, preferably maintaining a moderate degree of negative pressure.

GENERAL COMMENTS: *If a lobectomy has been planned, technical difficulties that lead to resection of the entire lung must not be countenanced.* The goal of the operation is conservation of normal lung tissue as well as ablation of the diseased focus. Interlobar fissures that have been obliterated by adhesions, or anatomically incomplete fissures, *can and must be developed* by careful dissection. Discovery of healed foci in adjacent lobes is not an indication for resecting them.

From a technical standpoint total pneumonectomy is a more rapid and simple procedure than individual ligation lobectomy. Obviously, it has no place in this discussion as an alternative to artificial pneumothorax or thoracoplasty in dealing with unilobar tuberculosis.

Discussion: Collapse therapy is eminently satisfactory in a high percentage of cases of pulmonary tuberculosis that require radical therapy. Its hazards are computable and by no means excessive. It has lightened but not eliminated the great economic and temporal wastage of the disease.

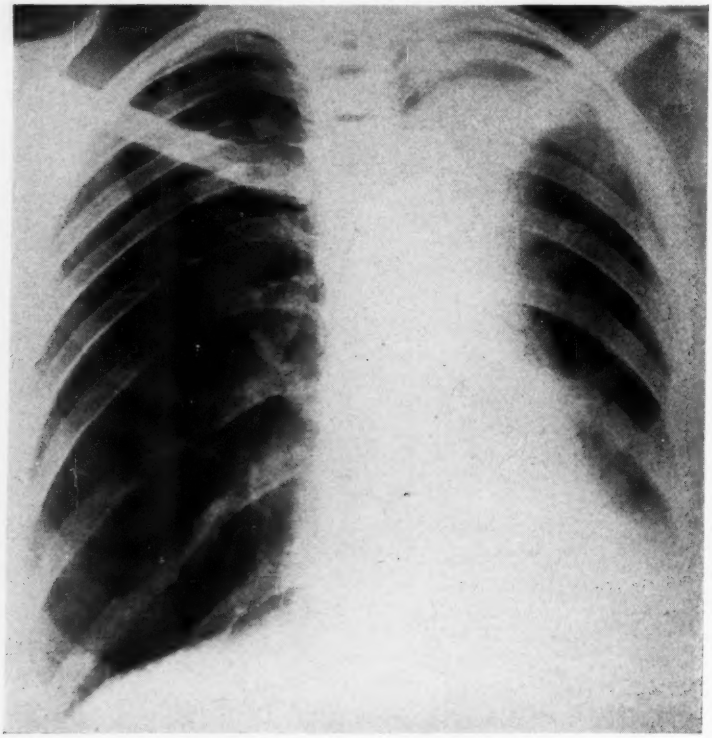

Fig. 6f.—Postoperative, January 15, 1943, three months after left upper lobectomy. There is one large and a few small calcifying foci visible in the apex of the reexpanded lower lobe but no active pathology discernible.

It may, for an indefinite period, remain the best form of treatment for the vast majority of patients requiring surgical intervention.

Before factual data are at hand to establish the safety of lobectomy as contrasted with thoracoplasty or long-continued artificial pneumothorax, it may seem mischievous to speculate regarding the theoretic advantages of such a procedure. A shortening of the span of treatment is not the least of these. Conversion of the personality all too frequently accompanies conversion of the sputum when the latter is attained at the expense of years of invalidism.

But from the more concrete physical point of view there are certain things to be gained. Lobectomy is more highly selective than thoracoplasty and as selective as the most skillfully managed pneumothorax, assuming in the

latter instance that healing and reexpansion are prohibited by the actual pathology. The functional capacity of the remaining lobe, or lobes, in the diseased side is preserved rather than encroached upon by long continued artificial pneumothorax or thoracoplasty.* The anatomic integrity of the thoracic cage and shoulder girdle remains essentially intact.

Most important of all, however, is the immediate ablation of the offending lesion in its entirety. This does not mean, of course, that the disease, tuberculosis, can be totally excised in many instances. While the open lesion under attack may represent only one manifestation of a generalized disease, there is reason to believe that its removal may aid rather than deleteriously affect remote latent or quiescent foci.

Surgeons familiar with tuberculosis will not need to be reminded that resection can only be considered after the patient's immunologic equilibrium has been restored by rest under a sanatorium regimen. Empyema, bronchial fistula, and implantation in the incision may otherwise be expected.

Artificial pneumothorax is in no way incompatible with subsequent lobectomy. When bed-rest alone is insufficient to bring the disease under control, pneumothorax or phrenic nerve paralysis may be added. If there is good reason to believe that the therapeutic goal of a reexpanded lung, with a closed lesion, cannot be achieved within a reasonable length of time, lobectomy may be considered when the acute phase has been brought under control.

CONCLUSIONS

Six cases of pulmonary tuberculosis are presented, three of which provided orthodox indications for resection of the lesion by lobectomy. Three others presented the usual indications for thoracoplasty but lobectomy was performed by election.

Healing *per primam* was the result in all instances.

Lobectomy provides a more selective and immediate method of eradicating certain lesions of tuberculosis than does collapse therapy. It may be used subsequent to artificial pneumothorax, thereby restoring to that procedure the reputation of finesse that it should enjoy.

A method of treatment that combines conservation of lung function, with immediate conversion of the sputum, and a shortening of the span of treatment, cannot be dismissed until its scope has been more fully explored.

REFERENCES

[1] Kayne, George Gregory, Pagel, Walter, and O'Shaugnessy, Laurence: Pulmonary Tuberculosis: Pathology, Diagnosis, Management and Prevention. Oxford University Press, London, New York, Toronto, 1939.

[2] Kent, Edward M., and Blades, Brian: The Surgical Anatomy of the Pulmonary Lobes. Jour. Thor. Surg., **12**, 18, October, 1942.

[3] Thornton, T. F., Jr., and Adams, W. E.: The Resection of Lung Tissue for Pulmonary Tuberculosis. Surg. Gynec. & Obst., **75**, 312, October, 1942.

* The apex of the lower lobe lies at the level of the fourth rib in the paravertebral gutter. Modern "apical" or "selective" thoracoplasties rarely spare the sixth rib, and usually extend to include the seventh.

THE LOCAL EFFECT OF SULFANILAMIDE, SULFATHIAZOLE AND SULFADIAZINE UPON HEMOLYTIC STAPHYLOCOCCUS AUREUS INFECTIONS OF THE PLEURAL CAVITY

ROLLIN A. DANIEL, JR., M.D., F. T. BILLINGS, M.D.,*

AND

RICHARD R. CRUTCHER, M.D.†

NASHVILLE, TENN.

FROM THE DEPARTMENTS OF SURGERY AND MEDICINE, VANDERBILT UNIVERSITY SCHOOL OF MEDICINE, NASHVILLE, TENN.

ALLBRITTEN, FLICK AND GIBBON[1] recently reported upon the use of sulfanilamide in patients subjected to lobectomy or total pneumonectomy. The patients were given the drug by mouth on the day preceding operation and administration was continued postoperatively. In seven patients treated in this manner, four developed empyema. In ten patients, sulfanilamide was also placed in the pleural cavity after excision of the diseased lobe or lung. Eight of these patients developed empyema. Individual ligation of the hilar structures was performed in six lobectomies, and in six other lobectomies mass ligation of the hilum was employed. Empyema occurred in four patients in each group. Burford and Graham[2] published their clinical experience with the use of sulfanilamide in the pleural cavity following the removal of one or more lobes of the lung. Individual ligation of the hilar structures was employed in eight patients, and in all of these the bronchus remained closed. None of these patients developed empyema. Mass ligation of the hilum was performed in 14 cases, and the bronchus subsequently opened in every patient. Empyema occurred in all of these patients. They believe that "where contamination at the time of operation is rather gross, but where the bronchus may be reasonably expected to remain closed, the drug very likely has value in preventing an empyema."

Kent and Graham[3] reported experimental observations on the prevention of empyema in dogs, produced by contamination of the pleura with putrid pus obtained from patients with empyema. The material was placed in the pleural space through an intercostal incision and lung tissue was not removed. Six groups of experiments were performed, with four animals in each group. Two cubic centimeters of pus was placed in every animal. The first group of four dogs received no drug. All died of empyema. In the second group, four grams of sulfanilamide was also placed in the pleural space. The same amounts of sulfapyridine, sulfathiazole and sulfaguaindine were used

* Captain F. T. Billings, M.C., U. S. Army.

† Captain Richard R. Crutcher, M.C., U. S. Army.

The sulfanilamide and sulfathiazole used in this work were supplied by E. R. Squibb & Sons, New York.

The sulfadiazine used in this work was supplied by Lederle Laboratories, New York, and E. R. Squibb & Sons, New York.

in the third, fourth and fifth groups, respectively. In the sixth group, a mixture of one gram of each of the above drugs was placed into the chest of each animal. All of the 20 treated animals recovered, and no evidence of infection was found when they were autopsied three weeks later.

The experiments presented in this report were undertaken to determine the relative effectiveness of the more commonly used sulfonamide drugs when employed locally, following experimental pneumonectomy in dogs. The hemolytic *Staphylococcus aureus* was employed as the infecting organism.

TABLE I

RESULTS OF INJECTION OF 4 CC. OF A 24-HOUR BROTH CULTURE + 8 CC. AGAR COMPARED WITH THOSE AFTER TREATMENT WITH SULFATHIAZOLE

4 Cc. 24-Hour Broth Culture + 8 Cc. Agar				Sulfathiazole			
Controls: No Drug Used				0.3 Gm. Sulfathiazole Per Kg. Body Weight			
Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity	Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity
1	24 hours	Empyema	H. *Staph. aureus*	2	6 days	Massive pleural effusion (1000 cc.)	No growth
3	4 days	Empyema	H. *Staph. aureus*	4	6 days	No cause apparent	No growth
5	4 days	Empyema	H. *Staph. aureus*	6	14 days	Empyema	H. *Staph. aureus*
7	4 days	Empyema	H. *Staph. aureus*	8		Sacrificed: 2 months	No growth
9	4 days	Empyema	H. *Staph. aureus*	10		Sacrificed: 2 months	No growth
11	6 days	Empyema	H. *Staph. aureus*	12		Sacrificed: 2 months	No growth
				13		Sacrificed: 2 months	No growth
Total No. dogs: 6. Died of empyema: 6				Total No. dogs: 7. Died of empyema: 1			

EXPERIMENTAL PROCEDURES

Normal dogs were used which varied in weight from 6 to 14 kilograms. The left chest wall was shaved and prepared with soap and water, and iodine and alcohol. Intravenous nembutal anesthesia was administered. Intermittent insufflation of air was administered through an intratracheal catheter.

Strict aseptic precautions were observed throughout the operative procedure. An incision was made in the left sixth intercostal space. The ribs were spread apart by means of a self-retaining retractor. The pulmonary vessels were divided between transfixing ligatures of silk. The bronchus was divided obliquely, and closed with interrupted fine silk sutures. The bronchial stump was then covered with a piece of mediastinal pleura. The organisms and drugs were placed in the pleural space through the open wound. The retracted ribs were then brought together by means of two encircling, fine stainless steel wire sutures. The soft tissues were closed in layers with interrupted sutures of fine silk.

Animals which died less than 12 hours after operation are not included in this study.

The amount of infectious material required as a minimal lethal dose varied in different groups of experiments. The animals in Table I were operated upon in groups of two, organisms being placed into the chest of one dog and the organisms and drug into the other. Animals of approximately

the same weights were used in each of these groups. Four cubic centimeters of a 24-hour blood broth culture of hemolytic *Staphylococcus aureus,* mixed with eight cubic centimeters of warm agar, were used. Table II represents a group of 12 animals, all operated upon during the same day. Organisms of known virulence were in this way used in control animals and in animals in which sulfonamide therapy was used. Tables III and IV are groups of experiments carried out in the same way.

TABLE II

RESULTS OF INJECTION OF 0.25 CC. OF A 24-HOUR BROTH CULTURE COMPARED WITH THOSE AFTER TREATMENT WITH SULFANILAMIDE

0.25 Cc. 24-Hour Broth Culture				Sulfanilamide			
Controls: No Drug Used				0.3 Gm. Sulfanilamide Per Kg. Body Weight			
Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity	Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity
14	36 hours	Empyema	H. *Staph. aureus*	15	24 hours	Empyema	H. *Staph. aureus*
16	48 hours	Empyema	H. *Staph. aureus*	17	24 hours	Empyema	H. *Staph. aureus*
18	48 hours	Empyema	H. *Staph. aureus*	19	24 hours	Empyema	H. *Staph. aureus*
20	3 days	Empyema	H. *Staph. aureus*	21	2 days	Empyema	H. *Staph. aureus*
22	4 days	Empyema	H. *Staph. aureus*	23	5 days	Empyema	H. *Staph. aureus*
24	5 days	Empyema	H. *Staph. aureus*	25	Living (3 mos.)		
Total No. dogs: 6. Died of empyema: 6.				Total No. dogs: 6. Died of empyema: 5.			

TABLE III

RESULTS OF INJECTIONS OF 0.25 CC. OF A 24-HOUR BROTH CULTURE COMPARED WITH THOSE AFTER TREATMENT WITH SULFATHIAZOLE

0.25 Cc. 24-Hour Broth Culture.				Sulfathiazole			
Controls: No Drug Used				0.3 Gm. Sulfathiazole Per Kg. Body Weight			
Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity	Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity
26	36 hours	Empyema	H. *Staph. aureus*	27	5 days	Bronchus open. No infection	No growth
28	48 hours	Empyema	H. *Staph. aureus*	29	6 days	Pneumonia, rt. No pleural infection	No growth
30	3 days	Empyema	H. *Staph. aureus*	31	10 days	Not determined. No infection	No growth
32	3 days	Empyema	H. *Staph. aureus*	33		Sacrificed: 12 days. Wound disrupted. No infection	No growth
34	5 days	Empyema	H. *Staph. aureus*	35	Living (3 mos.)		
36	Living (3 mos.)			37	Living (3 mos.)		
Total No. dogs: 6. Died of empyema: 5.				Total No. dogs: 6. Died of empyema: 0.			

TABLE IV

RESULTS OF INJECTION OF 0.25 CC. OF A 24-HOUR BROTH CULTURE COMPARED WITH THOSE AFTER TREATMENT WITH SULFADIAZINE

0.25 Cc. 24-Hour Broth Culture				Sulfadiazine			
Controls: No Drug Used				0.3 Gm. Sulfadiazine Per Kg. Body Weight			
Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity	Exper. No.	Duration of Life after Op.	Cause of Death	Culture of Pleural Cavity
38	3 days	Empyema	H. *Staph. aureus*	39	24 hours	Empyema	H. *Staph. aureus*
40	3 days	Empyema	H. *Staph. aureus*	41	24 hours	Empyema	H. *Staph. aureus*
42	3 days	Empyema	H. *Staph. aureus*	43	24 hours	Empyema	H. *Staph. aureus*
44	4 days	Empyema	H. *Staph. aureus*	45	Living (3 mos.)		
46	5 days	Empyema	H. *Staph. aureus*	47	Living (3 mos.)		
48	5 days	Empyema	H. *Staph. aureus*	49	Living (3 mos.)		
Total No. dogs: 6. Died of empyema: 6.				Total No. dogs: 6. Died of empyema: 3.			

In order to more definitely control the virulence of the organisms, experiments were performed upon 16 dogs with organisms which had been frozen at −78° C. (Table V). The organism was recovered from the pleural cavity of a dog with empyema. It was grown on large blood agar plates and washed from these plates with sterile normal saline solution after a growth-period of six hours. This suspension, thoroughly mixed, was placed in sterile pyrex ampules. The ampules, containing from one to two cubic centimeters of the suspension, were sealed by heat and placed immediately into 95 per cent alcohol in the freezing compartment. One cubic centimeter of this suspension contained approximately five billion bacteria.

TABLE V

RESULTS OF INJECTION OF 0.02 CC. (ABOUT 100 MILLION) OF FROZEN ORGANISMS COMPARED WITH THOSE AFTER TREATMENT WITH SULFANILAMIDE, SULFATHIAZOLE AND SULFADIAZINE

Frozen Organisms (In Saline Suspension): 0.02 Cc. (About 100 Million)

	Control: No Drug Used	Sulfanilamide 0.3 Gm. Per Kg. Body Weight	Sulfathiazole 0.3 Gm. Per Kg. Body Weight	Sulfadiazine 0.3 Gm. Per Kg. Body Weight
1	Died 20 hours. Empyema. Culture: H. *Staph. aureus*	Died 4 days Empyema Culture: H. *Staph. aureus*	Sacrificed 15 days. No infection. Culture: No growth	Living (2 months)
2	Died 5 days. Empyema. Culture: H. *Staph. aureus*	Died 6 days. Empyema-Wound disruption. Culture: H. *Staph. aureus*	Died 6 days. Wound disruption. No infection. Culture: No growth	Sacrificed 15 days. No infection. Culture: no growth
3	Died 4 days. Empyema. Culture: H. *Staph. aureus*	Sacrificed 14 days. No infection. Culture: No growth.	Died 5 days. Wound disruption. No infection. Culture: No growth	Living (2 months)
4	Sacrificed 14 days. No infection. Culture: No growth	Died 12 hours. Small amount fluid. Culture: H. *Staph. aureus*	Died 3 days. Empyema. Culture: H. *Staph. aureus*	Died 4 days. Empyema. Culture: H. *Staph. aureus*
Total No. dogs....	4	4	4	4
Total No. dead of empyema	3	3	1	1

TABLE VI

FATE OF ENTIRE GROUP OF DOGS INNOCULATED WITH MINIMAL LETHAL DOSE OF HEMOLYTIC STAPHYLOCOCCUS AUREUS FOLLOWING PNEUMONECTOMY

	Died of Empyema	Died of Other Cause. No Empyema	Lived	Total No. Dogs	Per Cent Dying of Empyema
Controls: No drugs used.....	26	0	2	28	92.9 per cent
Sulfanilamide 0.3 Gm. per Kg. body weight..	8	0	2	10	80.0 per cent
Sulfathiazole 0.3 Gm. per Kg. body weight..	2	8	7	17	11.8 per cent
Sulfadiazine 0.3 Gm. per Kg. body weight..	4	0	6	10	40.0 per cent

In Table VI the animals were operated upon in groups of four. Two-hundredths of a cubic centimeter of the organism suspension was placed in the pleural cavity of each dog. One animal was used as a control and the other three were subjected to the intrapleural application of sulfanilamide, sulfathiazole and sulfadiazine.

Pneumonectomy was performed upon 14 dogs which were not contaminated with the organisms. The effect of the sulfonamides upon the pleura were noted in 11 of these animals.

Sulfanilamide, sulfathiazole and sulfadiazine are the drugs which were employed. Three-tenths of a gram per kilogram of body weight was chosen as the amount of drug to be used in all experiments. Finely powdered crystals of the drug were poured through the wound over the surface of the mediastinal pleura immediately after introduction of the organisms.

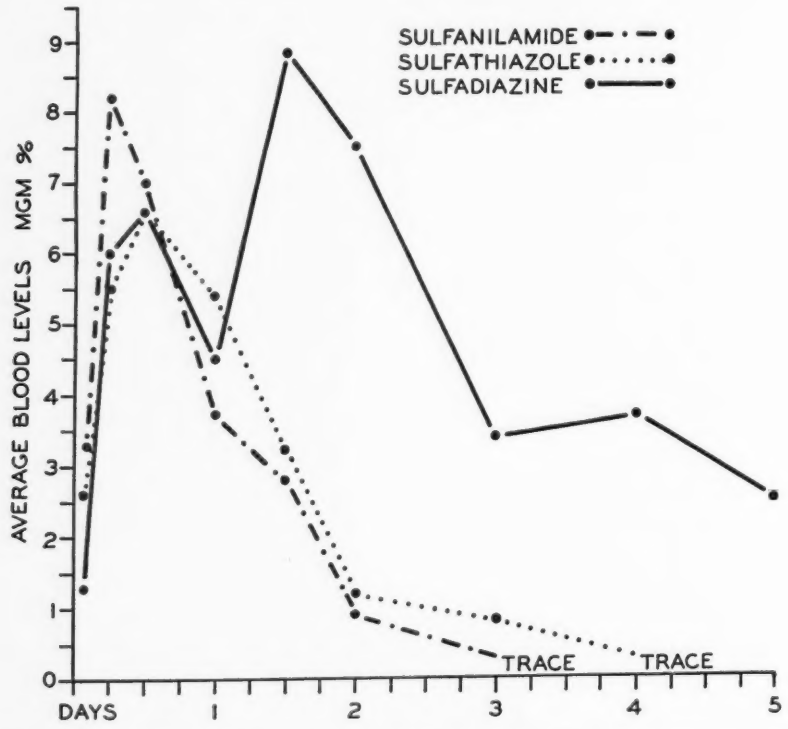

CHART 1.—Graphic representation of the effects of sulphonamide therapy on the blood concentration. (Recorded in milligrams per 100 cc. of blood.)

The blood concentration determinations were recorded in milligrams per 100 cc. of blood, according to the method of Bratton and Marshall.[4] Average blood levels were computed, and are shown in Chart 1. These determinations were all made from animals contaminated with the organisms. The sulfanilamide and sulfadiazine curves represent average levels from five animals each, the sulfathiazole curves from eight animals.

RESULTS

THE EFFECT OF THE SULFONAMIDES ON THE PLEURA

Left total pneumonectomy was performed upon 11 dogs in which 0.3 Gm. of sulfonamide drug per Kg. of body weight was placed in the pleural

space. The animals tolerated the procedure well. They were sacrificed and examined at intervals after operation, with the following results:

Sulfanilamide.—Three dogs: Sacrificed on the fourth, eleventh and forty-fifth days after operation. The pleura was clean and glistening in all. The pleural space was obliterated in the last animal, and there were a few adhesions present between the scar of the old wound of the chest wall and the mediastinal pleura. There was no fluid or drug present.

Sulfathiazole.—Five dogs: Sacrificed on the fourth, sixth, eighth and eleventh days. In the first, scattered small deposits of the drug were seen. The pleura was moist and glistening in all, and free fluid was not present. The fifth dog was autopsied four months after operation. The pleural space was obliterated and there were adhesions between the mediastinum and the scar of the chest wall. There was no fusion elsewhere.

Sulfadiazine.—Three dogs: Sacrificed five and sixteen days and ten weeks after operation. In the first, there were many fibrinous adhesions between the mediastinum and the pleura of the chest wall. Thirty cubic centimeters of thin bloody fluid and extensive scattered deposits of sulfadiazine were present. In the second, there were no adhesions, fluid or drug present. In the third animal there were many dense fibrous adhesions binding the mediastinal pleura to the lateral chest wall. No fluid or drug was present.

The appearance of the pleural space following the application of sulfanilamide and sulfathiazole was exactly comparable to three dogs subjected to pneumonectomy, in which no drug was placed in the pleural cavity. Evidence of definite and more violent inflammatory reaction followed the administration of sulfadiazine.

THE PREVENTION OF HEMOLYTIC STAPHYLOCOCCUS AUREUS INFECTIONS

The tables are arranged in the order in which the experiments were performed.

Sulfathiazole was the most effective of the three sulfonamides in the prevention of fatal empyema. Sulfadiazine appears to have been almost as efficacious as sulfathiazole. Sulfanilamide offered the least protection against the infection.

Cultures of the heart's blood were obtained from two animals (one control and one treated animal) in each group which died of empyema. These cultures all remained sterile.

The maintenance of a high blood level of sulfadiazine for a period of five days is interesting. It should be noted that sulfanilamide and sulfathiazole disappeared from the blood stream in nearly the same period of time after operation despite the difference in the occurrence of fatal empyema in the two groups of animals.

Disruption of the chest wound occurred in three animals in the sulfathiazole group and in one in which sulfanilamide was used. The wound was

not disrupted in any of the control animals (28 dogs) although all but two developed fatal empyema.

SUMMARY AND CONCLUSIONS

1. The effects of sulfanilamide, sulfathiazole and sulfadiazine upon the pleural cavity following pneumonectomy has been studied in the dog.

2. The local effects of sulfanilamide, sulfathiazole and sulfadiazine upon the prevention of hemolytic staphylococcus infection in the pleural cavity of the dog, following pneumonectomy, have been studied.

3. There is little gross local evidence of reaction to sulfanilamide or sulfathiazole used in the pleural cavity following pneumonectomy. Sulfadiazine produces a more marked inflammatory reaction than do the other drugs.

4. The local use of sulfathiazole is more effective in preventing hemolytic staphylococcus empyema following pneumonectomy in the dog than are either sulfanilamide or sulfadiazine. The local use of sulfanilamide is least effective in prevention of this infection.

5. The absorption of sulfanilamide from the contaminated pleural cavity takes place slightly more rapidly than does sulfathiazole. The absorption of sulfadiazine occurs much more slowly than either of the other drugs.

6. A greater incidence of wound disruption in animals in which sulfathiazole was used suggests that this drug may have interfered with the healing of the wounds.

REFERENCES

[1] Allbritten, F. F., Flick, J. B., and Gibbon, J. H., Jr.: The Use of Sulfanilamide in Partial and Total Resection of the Lung. J. Thor. Surg., **11**, 187, 1941.

[2] Burford, T. H., and Graham, E. A.: The Local Use of Sulfanilamide in the Pleural Cavity. J. Thor. Surg., **11**, 203, 1941.

[3] Kent, E. M., and Graham, E. A.: Experimental Observations on the Use of Drugs of the Sulfonamide Group in the Pleural Space. J. Thor. Surg., **11**, 198, 1941.

[4] Bratton, A. C., and Marshall, E. K., Jr.: A New Coupling Component for Sulfanilamide Determinations. J. Biol. Chem., **128**, 537, 1939.

THE EFFECT OF SULFANILAMIDE, SULFATHIAZOLE AND SULFADIAZINE UPON THE PERITONEUM

RICHARD R. CRUTCHER, M.D.,* ROLLIN A. DANIEL, JR., M.D.,
AND
F. T. BILLINGS, M.D.†
NASHVILLE, TENN.

FROM THE DEPARTMENTS OF SURGERY AND MEDICINE, VANDERBILT UNIVERSITY SCHOOL OF MEDICINE, NASHVILLE, TENN.

THE INTRAPERITONEAL use of the sulfonamides is now practiced widely for the treatment and prevention of infection. Sulfanilamide has been most frequently used and is said not to produce any evidences of foreign body reaction. Harbison and Key[1] implanted large doses of sulfanilamide, sulfathiazole and sulfadiazine (500 mg.) into the abdominal cavities of rats and found no evidence of inflammatory reaction to any of these drugs or to mixtures of sulfanilamide and sulfathiazole after 28 days.

Jackson and Coller[2] present a series of experiments carried out on dogs, sulfanilamide being implanted and peritoneal fluid being examined for cellular response. The peritoneal cavities were examined from four hours to one month later. They found no evidence of reaction to the drug. In the discussion of this article Ochsner stated that sulfanilamide produces intense inflammation in the abdominal wounds of patients, and this opinion was emphasized by Coller.

Laird and Stavern[3] performed 11 experiments on seven dogs, sulfanilamide being implanted in three dogs, sodium sulfathiazole in four and, later, sulfathiazole in the first three. Evidence of marked inflammation was noted after the use of sodium sulfathiazole, none in the other experiments. One-half gram of each drug per kilogram of body weight was used and the dogs were examined at the end of two, four and eight weeks.

The articles of Ravdin, Rhoads and Lockwood,[4] Muller and Thompson,[5] and of Jackson and Coller,[2] are illustrative of the improved clinical results which are attributed to the local use of the sulfonamides in the treatment of peritonitis.

The experiments presented in this report were undertaken preparatory to the experimental study of the effect of the sulfonamides on infections of the peritoneal cavity.

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* Captain Richard R. Crutcher, M.C., U. S. Army.

† Captain F. T. Billings, M.C., U. S. Army.

The sulfanilamide and sulfathiazole used in this work were supplied by E. R. Squibb & Sons, New York.

The sulfadiazine used in this work was supplied by Lederle Laboratories, New York, and E. R. Squibb & Sons, New York.

METHOD OF STUDY

Fifty-five dogs were used. The effect of sulanilamide, sulfathiazole and sulfadiazine placed in the peritoneal cavities was determined. It was noted prior to these experiments that when finely powdered crystals of sulfathiazole were poured into the peritoneal cavities of dogs, a part of the drug tended to become "walled-off" by the omentum into a mass or lump, which when removed was often quite hard, and when this occurred a part of this lump might remain for as long as four days. It was also noted that when very finely powdered drug was used this tendency to form lumps was more marked than when coarse crystals were used. When this occurred adhesions between loops of intestine were more apt to be found later. Attention has been directed to this by Throckmorton,[7] in a thorough study of the cellular response to various drugs in the peritoneal cavity of the albino rat.

The method of introduction of the drug was varied as follows: In one group finely powdered crystals of the drug were scattered about over the loops of intestine. In a second group, the drug was suspended in about 50 cc. of sterile distilled water, and this was poured through the wound among the loops of intestine. In the third group, a weighed amount of drug was moistened with distilled water and then allowed to dry. In this way a hard lump of the drug was formed. This was broken into four or five pieces and these lumps were placed among the loops of intestine.

In all experiments 0.3 Gm. of drug per kilogram of body weight were used.

The drug was introduced through a short right paramedian abdominal incision, under intravenous nembutal anesthesia. The operation was performed under aseptic conditions. The omentum was delivered through the wound and the small bowel was carefully examined for the presence of adhesions. After the omentum was replaced in the abdominal cavity the wound was closed in layers with interrupted fine silk sutures.

The abdomen was reopened at varying periods of time after the introduction of the drugs. In some instances this was done after the animal was sacrificed. In others a left paramedian incision was made under nembutal anesthesia and under aseptic conditions, the entire intestinal tract was carefully examined and the incision closed. These animals were then examined again later.

In none of the experiments included in this study was there any evidence of infection of the wound or the peritoneum postoperatively.

The blood content of the drugs was determined at intervals of several hours after the original operation, by method of Bratton and Marshall.[6]

RESULTS

Four animals were operated upon in which the intestines were examined but no drug was introduced. Later examination (5–14 days after operation) showed no adhesions or other evidences of inflammation.

FIG. 1.—Exper. No. 15: Sulfanilamide lumps. Appearance 35 days after implantation of drug.

FIG. 2.—Exper. No. 38: Sulfathiazole lumps. Appearance 54 days after implantation of drug.

FIG. 3.—Exper. No. 40: Finely powdered sulfadiazine. Appearance 45 days after implantation of drug.

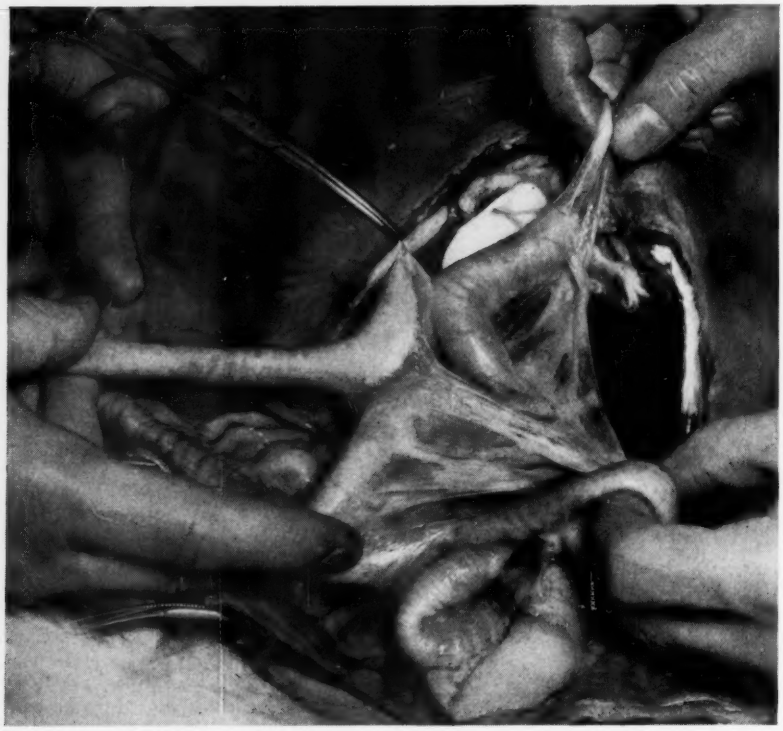


FIG. 4.—Exper. No. 43: Suspension of sulfadiazine. Appearance 35 days after operation.

TABLE I

FINELY POWDERED CRYSTALS

Exper. No.	Time of Examination after Drug Implantation	Number and Character of Adhesions	Visible Drug Remaining
Sulfanilamide.... 1	5 days	None	None
2	5 days & 36 days	Slight 5 days; none 36 days	None
3	5 days & 66 days	None	None
4	11 days	None	None
5	98 days	None	None
Sulfathiazole.....18	4 days	None	None
19	5 days & 6 months	None	None
20	6 days	None	None
21	9 days & 31 days	Marked 9 days; slight 31 days	None
22	11 days	None	None
23	22 days	None	None
24	13 days & 91 days	None	None
25	13 days	Slight 13 days; none 91 days	None
26	13 days	None	None
27	9 days	Slight	None
28	13 days	None	None
Sulfadiazine.....39	10 days	None	None
40	8 & 45 days	Marked: 8 & 45 days	Several small lumps, 8 days
41	10 & 45 days	Marked: 10 & 45 days	None
42	8 & 45 days	Marked: 8 & 45 days	1 small lump, 8 days

TABLE II

FINELY POWDERED CRYSTALS SUSPENDED IN STERILE DISTILLED WATER (ABOUT 50 CC.)

Exper. No.	Time of Examination after Drug Implantation	Number and Character of Adhesions	Drug Remaining
Sulfanilamide.... 6	4 days	None	None
7	4 days	2 small (omentum-bowel)	None
8	7 days	None	None
9	7 days	None	None
10	7 days	None	None
11	11 days	None	None
Sulfathiazole.....29	9 & 31 days	Slight 9 days; none 31 days	None
30	9 & 31 days	None	None
31	9 & 31 days	None	None
32	9 & 31 days	Slight: 9 & 31 days	None
33	9 & 31 days	Slight: 9 & 31 days	None
Sulfadiazine.....43	6 & 36 days	Marked: 6 & 36 days	None
44	6 & 36 days	Moderate: 6 & 36 days	None
45	12 days	Moderate	None
46	12 days	None	None
47	20 days	None	None
48	28 days	None	None
49	28 days	None	None

TABLE III

LUMPS

Exper. No.	Time of Examination after Drug Implantation	Number and Character of Adhesions	Drug Remaining
Sulfanilamide....12	9 days	Moderate	None
13	9 days & 34 days	Moderate	None
14	9 days & 34 days	Moderate	None
15	9 days & 34 days	Moderate	Small lump at 9 days
16	8 days	None	None
17	28 days	None	None
Sulfathiazole.....34	5, 62 & 91 days	Marked: 5, 62 & 91 days	1 large lump at 5 days
35	3 & 37 days	Moderate 3 days; none 37 days	4 small at 3 days
36	12 days	Moderate	None
37	20 days	Moderate	None
38	37 days	Moderate	2 small lumps
Sulfadiazine.....50	20 days	Marked	1 large lump
51	20 days	Marked	None

The findings in the peritoneal cavities of the animals are summarized in Tables I, II and III. The persistent evidence of peritoneal reaction was based upon the presence of adhesions existing between the omentum and the bowel, but adhesions between the scar of the wound of the abdominal wall and the omentum or the viscera were disregarded. The reaction was graded as follows: "Slight," indicating the presence of from one to four narrow or filmy adhesions; "moderate," indicating the presence of several dense bands of adhesions; and "marked," indicating widespread dense adhesions.

There was evidence of peritoneal reaction in at least one animal in all of the groups of experiments. The adhesions first noted after the use of fine crystals of sulfanilamide and sulfathiazole had disappeared when the animals were examined later, with the possible exception of Exper. No. 27. This animal was sacrificed on the ninth postoperative day. In Exper. No. 7 (sulfanilamide in suspension), the dog was sacrificed on the fourth day. It is probable that the two small adhesions noted there would have subsequently disappeared. With the exception of this one experiment, no adhesions were noted after the use of sulfanilamide in suspension, whereas adhesions were present nine days after operation in three out of five animals used in the sulfathiazole suspension group, and these adhesions persisted in two animals for 31 days.

When lumps of the drug were used the reaction was similar to that which is seen to occur about any foreign material. Moderate to marked adhesions were formed which persisted, but the reaction was less marked with sulfanilamide than with the other drugs.

Numerous adhesions occurred following the use of sulfadiazine in all three groups of experiments, but they appeared to be less marked when the suspension was used.

When lumps were used, small portions of the drug were occasionally still present several days after they were introduced. Two small lumps of sulfathiazole were found in the center of a mass of adhesions 37 days after operation and a large mass of sulfadiazine was found 20 days after.

The average blood levels of the drugs were computed for each group, and these average curves are shown in Charts 1, 2 and 3. As might be expected, sulfanilamide was absorbed rapidly and remained in the blood stream for a shorter period of time than did the other drugs. A considerably higher concentration of the drug was obtained with sulfadiazine than with the other drugs. A correlation of absorption rate and the local evidences of reaction to the different drugs is possible, and it may be that the absence of severe reaction to the implantation of sulfanilamide is due to the ability of the animal to rapidly absorb and excrete the drug. Sulfadiazine might be expected to be most beneficial in the treatment or prevention of infection because of its slow absorption rate and persistent high local concentration. On the other hand, it produces evidence of considerable damage to the tissues, possibly by persisting longer as foreign material.

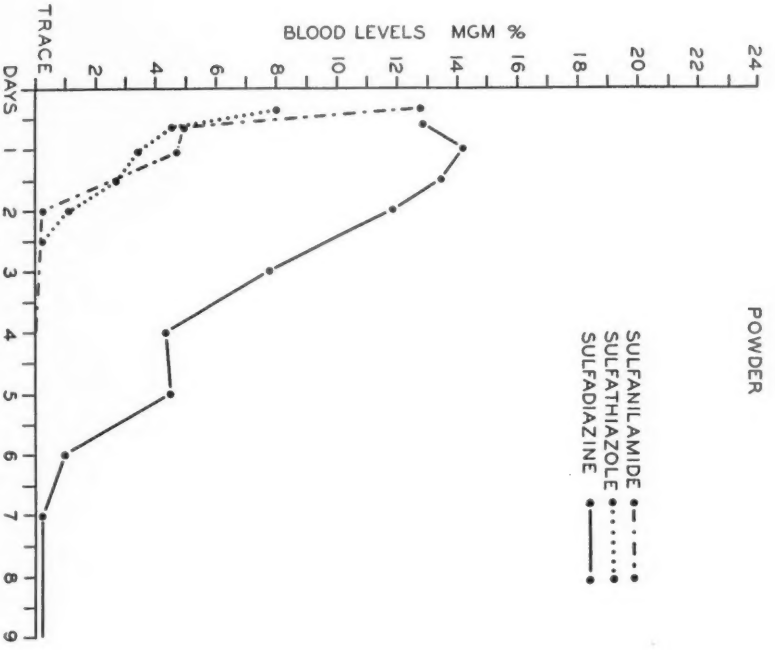


CHART 1.—Graphic representation of the effects of sulfonamide therapy on the blood concentration when applied as a powder.

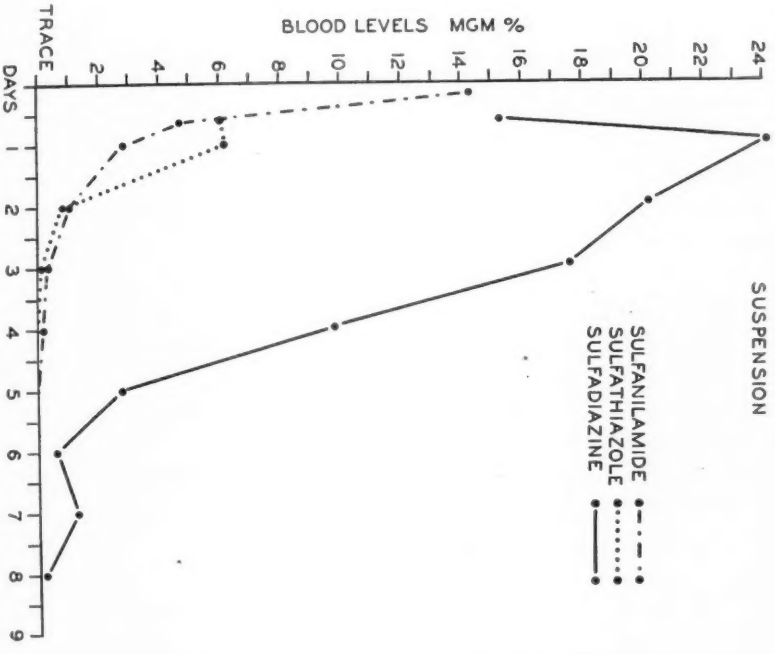


CHART 2.—Graphic representation of the effects of sulfonamide therapy on the blood concentration when applied in suspension.

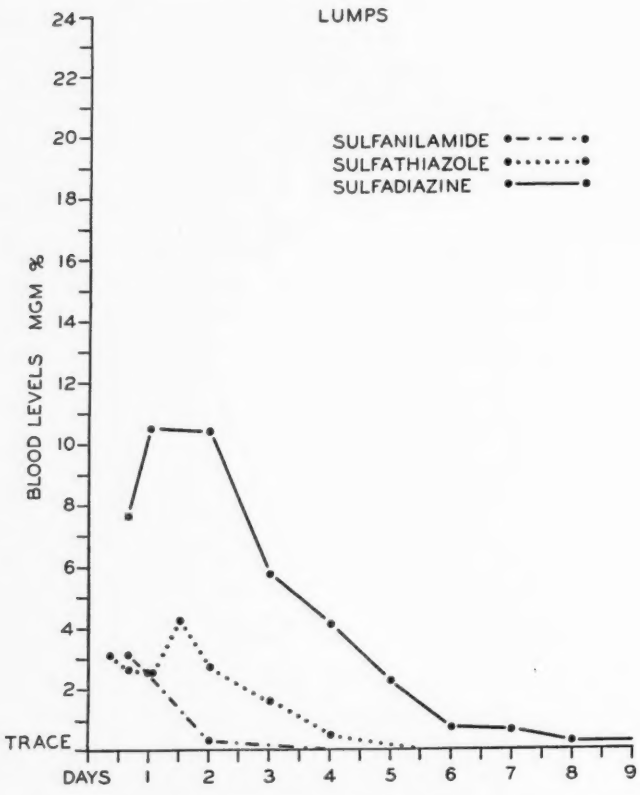


CHART 3.—Graphic representation of the effects of sulfonamide therapy on the blood concentration when applied in lumps.

CONCLUSIONS

1. Sulfanilamide, sulfathiazole and sulfadiazine may all produce adhesions within the peritoneal cavity of the dog under certain conditions. These adhesions may be persistent for long periods of time.

2. Masses of the drugs are apt to become "walled-off" as a foreign body and be absorbed very slowly.

3. Care should be taken to distribute the finely powdered drug evenly about the available surface of the peritoneum to avoid the formation of lumps. This may be easily accomplished by introducing the drug in a suspension of sterile water or saline.

4. Sulfadiazine produces much greater local reaction than sulfanilamide or sulfathiazole.

5. The absorption of sulfadiazine from the peritoneal cavity occurs more slowly than does the absorption of sulfanilamide or sulfathiazole.

REFERENCES

[1] Harbison, S. P., and Key, J. A.: Local Implantation of Sulfanilamide and its Derivatives in Wounds: Its Relation to Wound Healing and to Peritoneal Adhesions. Arch. Surg., **44**, 22, 1942.

2 Jackson, H. C., and Coller, F. A.: The Use of Sulfanilamide in the Peritoneum. J. A. M. A., **118**, 194, 1942.

3 Laird, G. J., and Stavern, H.: Intraperitoneal Use of the Sulfonamides. Cal. and Western Med., **56**, 293, 1942.

4 Ravdin, I. S., Rhoads, J. E., and Lockwood, J. S.: The Use of Sulfanilamide in the Treatment of Peritonitis Associated with Appendicitis. ANNALS OF SURGERY, **111**, 53, 1940.

5 Mueller, R. S., and Thompson, J. E.: The Local Use of Sulfanilamide in the Treatment of Peritoneal Infections. J. A. M. A., **118**, 189, 1942.

6 Bratton, A. C., and Marshall, E. K., Jr.: A New Coupling Component for Sulfanilamide Determinations. J. Biol. Chem., **128**, 537, 1939.

7 Throckmorton, T. D.: The Peritoneal Response to Locally Implanted Crystalline Sulfonamide Compounds. Surgery, **12**, 906, 1942.

PREVENTION OF SHOCK AND DEATH BY IMMEDIATE APPLICATION OF A PRESSURE DRESSING TO THE SEVERELY FROZEN LIMBS OF DOGS

AN EXPERIMENTAL STUDY

EGBERT H. FELL, M.D., AND RUSSELL HANSELMAN, M.D.
CHICAGO, ILL.

FROM THE SURGICAL SERVICE, PRESBYTERIAN HOSPITAL, CHICAGO, ILL.

THE GLOBAL WAR has produced many problems. The reports from the various fronts and civil life concerning the serious results following burns, freezing, and crush injuries of extremities have challenged many to further study.

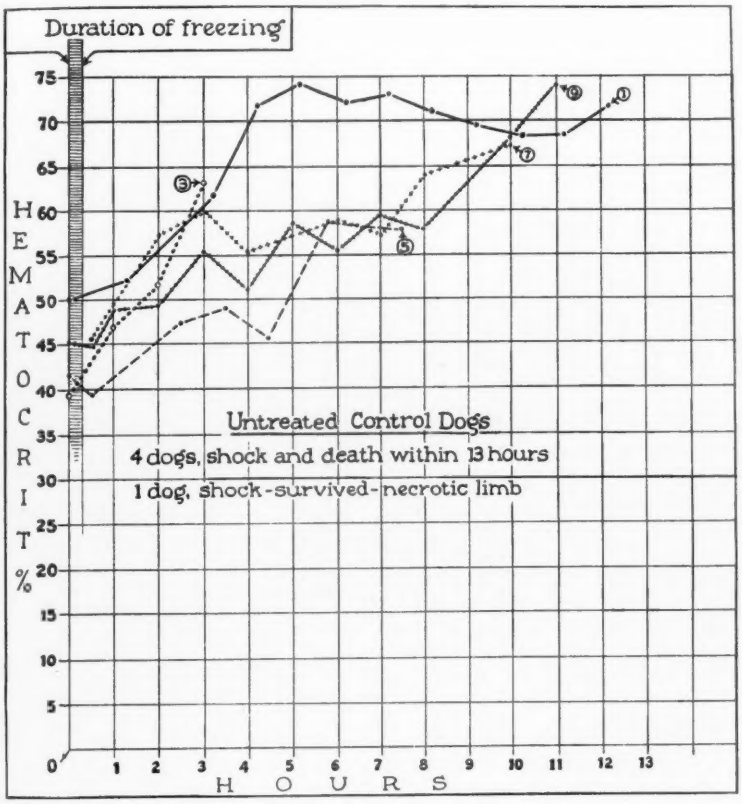
Various authors believe that the three injuries, although due to different causes, are followed by similar local and general reactions and, in the severe

FIG. 1.—Marked swelling of frozen extremity occurred, including the paw.

cases, local swelling soon takes place in a marked degree, often followed by shock and death. This study concerns the prevention of shock and death following a severe freezing injury to an extremity of dogs. Investigators have shown that severe freezing of a dog's extremity is followed by extensive local swelling of the injured part, clinical shock, and death in most cases.

Taking this method of producing these fatal reactions we chose only one form of therapy.

We have been convinced of the importance of pressure dressings for the burned patients and believe, as do Allen[14] and Koch,[13] that it not only provides a clean, closed wound but minimizes, if properly applied, local swelling, hemoconcentration, and shock, which may result in death. In addition, we wished to study in this experiment the importance of immediate application of a smooth, firmly applied pressure dressing. We have been impressed with



GRAPH 1.—Hematocrit curves of untreated dogs following freezing injury to right hind extremity.

the lack of emphasis placed on the emergency care of the local injured part and the great attention to intravenous and drug therapy. Blalock[4, 5] has shown that as much as two-thirds of the intravenous plasma administered to dogs with crushed extremities will be lost in or about the injury. Clinically and in the laboratory, shock and death usually follow the local swelling, and much debate has taken place as to whether this is due to local loss of fluids, toxic reaction, both, or a nervous mechanism.

In our experiments, ten dogs were anesthetized with pentabarbital sodium, and maintained under light anesthesia for 10–12 hours. The right hind extremities were immersed to the upper third of the thigh in a mixture

of carbon dioxide snow and 95 per cent alcohol, at −55° C., for 20 minutes. Within two minutes the entire portion was frozen. Five of the dogs received no form of therapy, the legs being allowed to thaw out at room temperature.

To the frozen hind legs of the other five dogs, two to three layers of sheet wadding were applied including the foot and toes, and over this was applied

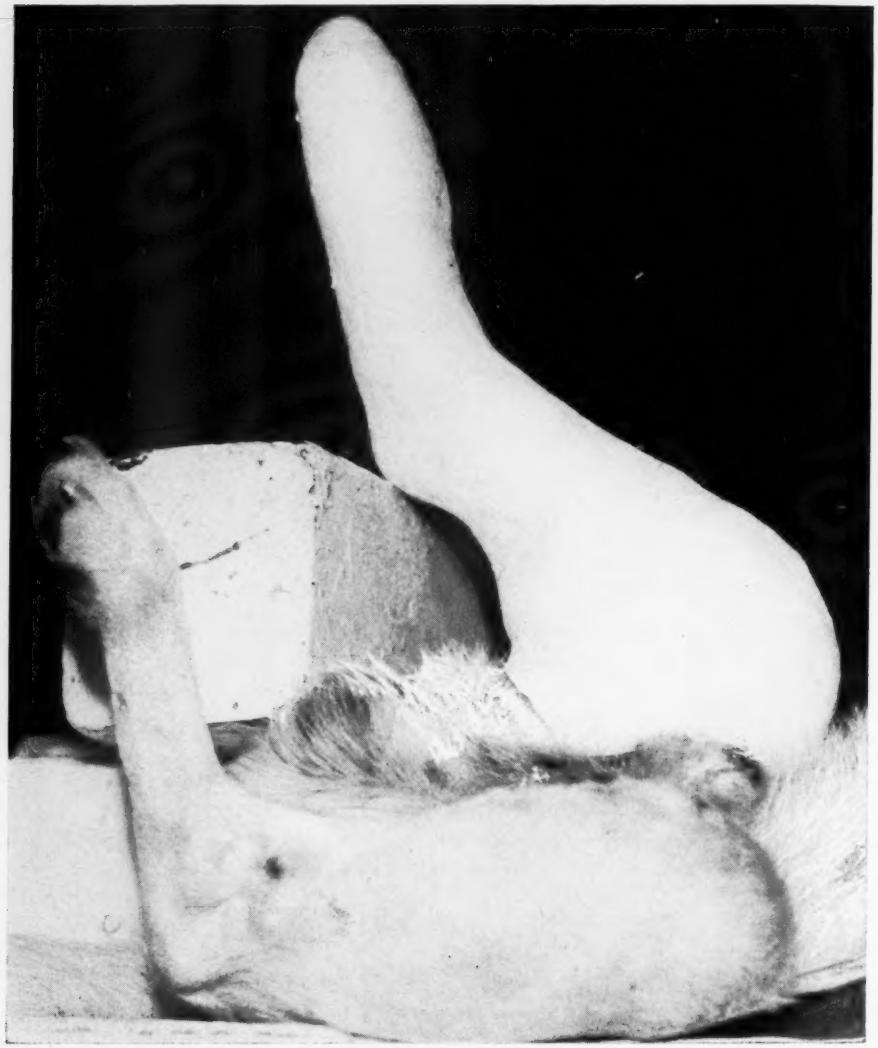
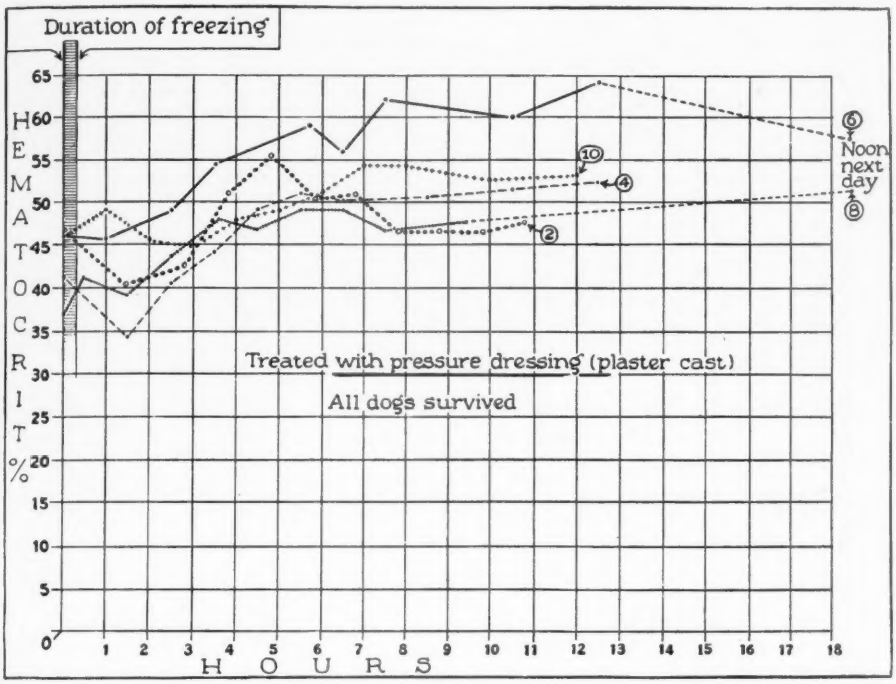


FIG. 2.—Plaster encasement pressure dressing.

smoothly and evenly a plaster encasement. An attempt was made to extend the encasement above the line of frozen tissue.

All five of the untreated dogs developed clinical shock, four of them dying within 13 hours. All of the treated dogs lived, and the maximum increase in the hematocrit was only about one-half as great as in the untreated group. Expressed numerically, the average maximum increase

in the hematocrit for the untreated animals was 23.1 points (52 per cent) increase, whereas in the treated group it was only 11.6 points (26 per cent) increase. The rectal temperatures taken directly after freezing showed a decrease of as much as 6° to 7° F. Blood pressures dropped to shock levels in the untreated dogs. Blood was taken at hourly intervals for hematocrit and plasma protein determinations. Plasma proteins were determined by the falling-drop method (Barbour and Hamilton). We recognize the marked loss of plasma into and about the injured tissues, but in our findings the blood plasma proteins were slightly increased. The increase in the per-



GRAPH 2.—Hematocrit curves of the plaster-encased treated animals.

centage of plasma protein was 1.45 for the untreated dogs and 0.56 for the treated.

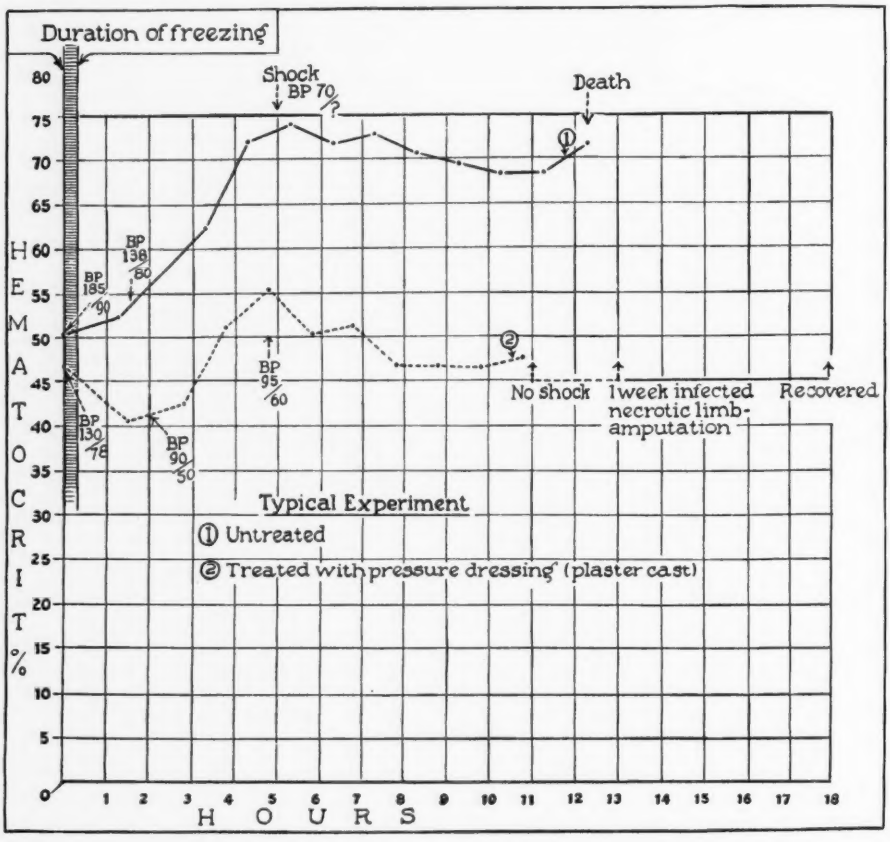
It is of considerable interest, and perhaps of importance, to have seen how slowly the encased legs thawed out; they were cold and moist for 12 hours or longer. We are not sure that the plaster encasement is the preferred method of application of a pressure dressing, but it does afford firm, even pressure splintage and allows for slow thawing.

Four of the five treated dogs developed necrotic limbs. One dog died nine days after freezing, from a secondary infection. Another dog died 14 days after freezing and seven days after a hip disarticulation. The cause of death was a generalized purulent peritonitis which may have been secondary to the wound infection. Two dogs had their necrotic infected extremities amputated 8 and 11 days after freezing, and made uneventful

recoveries. The fifth dog had his leg amputated 48 hours after freezing, and likewise recovered.

The plaster encasement of one of the treated dogs became loose, and on the third day it was removed. The leg became necrotic and required a disarticulation. The early removal of the pressure dressing brings up the problem of how long such dressings are necessary.

Sir Thomas Lewis[1] advises in the case of a frozen limb that its arteries



GRAPH 3.—Hematocrit curves of a typical experiment—treated and untreated animal.

may be compressed until thawing is complete and the compressing then be gradually relaxed to allow the blood to return to the limb little by little. There is every reason to believe that limbs less severely frozen than those of our experimental animals can be saved if the compression is uniformly applied to digits and extended above the line of injury just as it is applied to the early burn or wringer injuries.

Further studies are in progress regarding compression, burn, and less severe freezing injuries. Of importance, also, will be the study of compression dressings in cases of partially thawed out or edematous extremities associated with plasma or serum therapy.

We have substituted, in two additional cases, an elastic bandage (Acetype) firmly applied with splintage as a method of pressure dressing, with similar results both as to recovery and hematocrit and plasma protein changes.

It would seem that clinically we could apply the pressure dressings and splintage with advantage to the frozen, compressed, and burned patients. The time for such application is before swelling begins; in other words, immediately when the limb is released from the crushing load, directly after the burn, and before any thawing takes place in the frozen part. This, we believe, is as important as splintage of a fracture at the scene of injury and should be done with the most effective method at hand. Protection of skin and wounds and the prevention of sepsis must not be disregarded.

SUMMARY

The immediate, careful application of pressure dressings, (plaster encasement) prevented shock and death of five dogs whose right hind extremity had been severely frozen. The blood volumes, as determined by the hematocrit, were maintained in this group in levels not producing shock.

REFERENCES

1 Lewis, Sir Thomas: Observations on Some Normal and Injurious Effects of Cold upon the Skin and Underlying Tissues. Brit. Med. Jour., **2**, 869–871, December, 1941.

2 Harkins, Henry N., and Hudson, Jeanne E.: Shock Due to Freezing. Proc. Soc. Exp. Biol. and Med., **32** Part II, 434–435, 1934–35.

3 Harkins, Henry N.: Shock Due to Freezing: Shift of Body Fluids and Associated Blood Concentration Changes. Proc. Soc. Exp. Biol. and Med., **32**, Part I, 432–435, 1934–35.

4 Blalock, A.: Arch. Surg., **22**, 1610, 1931.

5 Blalock, Alfred: Effects of Lowering Temperature of an Injured Extremity to which a Tourniquet has been Applied. Arch. Surg., **46**, 167, February, 1943.

6 Duncan, G. W., and Blalock, A.: The Uniform Production of Experimental Shock by Crush Injury: Possible Relationship to Clinical Crush Syndrome. ANNALS OF SURGERY, **115**, 684, 1942.

7 Duncan, G. W., and Blalock, A.: Shock Produced by Crush Injury: Effect of Administration of Plasma and Local Application of Cold. Arch. Surg., **45**, 183, August, 1942.

8 Report of Royal Society of Medicine. Effects on Kidney of Limb Compression. Brit. Med. Jour., **2**, 884–885, December 2, 1941.

9 Bywaters, E. G. L.: Crushing Injury. Brit. Med. Jour., **2**, 643, November 28, 1942.

10 Bywaters, E. G. L., and Beall, D.: Crush Injuries with Impairment of Renal Function. Brit. Med. Jour., **1**, 427, March 22, 1941.

11 Beall, D., Bywaters, E. G. L., Belsey, R. H. R. and Miles, J. A. R.: A Case of Crush Injury with Renal Failure. Brit. Med. Jour., **1**, 432, March 22, 1941.

12 Mayon-White, R., and Solanet, O. M.: A Case of Limb Compression Ending Fatally in Uremia. Brit. Med. Jour., **1**, 434, March 22, 1941.

13 Koch, S. L.: Panel Discussion: Treatment of Burns. Bull. A. C. S., **27**, 106–108, April, 1942.

14 Allen, H. S., and Koch, S. L.: Treatment of Patients with Severe Burns. S. G. & O., **74**, 914–924, May, 1942.

15 Muirhead, D. E., Ashworth, C. T., Cregel, L. A., and Hill, J. M.: Experimental Freezing Shock: Changes in Body Fluids and Tissues. Arch. Surg., **45**, 863, December, 1942.

THE BLOOD CIRCULATION IN PEDICLE FLAPS*

AN ACCURATE TEST FOR DETERMINING ITS EFFICIENCY

BEVERLY DOUGLAS, M.D., AND RANSOM R. BUCHHOLZ, M.D.

NASHVILLE, TENN.

FROM THE DEPARTMENT OF SURGERY, VANDERBILT UNIVERSITY SCHOOL OF MEDICINE, NASHVILLE, TENN.

WHILE THE NERVE SUPPLY and reorientation of sensation is important in pedicle flaps it does not compare in importance with their blood circulation, an adequate degree of which is vital. A flap can be very useful without sensation but without blood supply its tissues cannot survive for more than a few hours.

Realizing the importance of the problem of blood supply in pedicle flaps which, in the course of reconstructive work, one is frequently called upon to use, we have studied several of the factors which have a bearing on determining the optimum time of transplanting the ends of flaps.

Dr. John Staige Davis defines a pedunculated or pedicle flap as "a mass of tissue, usually the skin and subcutaneous fat, which is raised from its bed but is left attached to the surrounding skin at a selected portion of its periphery." This is the sense in which we shall use the term, except that we should like to qualify it by saying that the pedunculated or pedicle flaps used in most of our experiments have been delayed pedicle flaps, *i.e.*, they have consisted of tubes or ropes of skin usually attached at both but sometimes only at one end, as shown in the accompanying illustrations.

We do not include in this report the special type of pedicle flap which contains a main artery and vein in a narrow pedicle, since in these the circulation is greatly enhanced over that of the ordinary flap in common use in plastic procedures.

On the other hand, we have been careful, as far as possible, in designing flaps to follow the direction of, rather than to cut across the normal course of the arteries and veins, and not to cut across the midline of the body.

It is our impression that the chief factors in the rapid "take" of flaps, by which we mean the ability of the flap tissue to survive the division of the pedicle for purposes of reattachment or shifting, is the development of (1) new vascular connections in the pedicle bed; and (2) progressive development of collateral connections in the direction of the long axis of the flap.

Since in this discussion we shall frequently employ the terms "pedicle skin flap" and "skin graft" we feel it advisable to state the difference in these two useful but very dissimilar forms of transplant. A skin graft is a portion of skin of variable thickness, without fat, which is cut entirely free and placed on a new site from which it must derive its nutrition in order to attach itself, develop its circulation, and survive. A pedicle flap or

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pedicle skin flap, on the other hand, is a mass of skin and underlying subcutaneous fat which is left attached at some part or parts of its periphery through which part, *viz.*, the pedicle or pedicles, the circulation and nutrition is obtained until the recently shifted pedicle may become attached to its new bed.

It is thus seen that in the skin graft no circulation, except perhaps a plasmatic circulation[1] is present for a considerable time after transplantation, whereas in the flap the tissue remains supplied with blood from one source or another at all times.

It is obvious that the tissue mass of all pedicle flaps (since they contain skin and fat) is much greater than in any skin graft and that they must, therefore, depend for their life upon an adequate blood supply. Unlike a free graft, such masses of tissue would almost never survive free transplantation. This statement is not made in any way to minimize the importance of reestablishment of circulation in the small vessels in the "take" of free grafts of Davis and Traut.[2] These authors removed small squares of skin and replanted them in their beds. In the first series they rotated the squares 90 degrees and obtained complete takes in 66 per cent, partial takes in 20 per cent and failure in 14 per cent. The second series of squares were rotated 180 per cent with the result that 80 per cent showed complete takes, 20 per cent partial, with no failures. The third, or control series of squares replaced without rotation, took in 100 per cent of the cases.

The work of Goodpasture, Douglas and Anderson[1] corroborates this for human skin grafts on chorio-allantois of chicks by showing a rapid reestablishment of vascular channels from chick membrane to human graft.

While in the case of certain organs, such as the ends of fingers, toes and parts of ears, it is a well known fact that with careful suturing large masses of tissue survive, this is the great exception and is probably due to the accurate matching of parts in a simple terminal system in such a way that arterial and venous flow is rapidly reestablished. For purposes of supplying such masses in reconstructive work, blood supply must be maintained through a pedicle or failure will result.

One of the chief objections to the transfer of tissue by the pedicle flap method has been the delay occasioned by the necessity for leaving the ends of the flap attached to a distant part such as the arm to the face. The splinting required makes such a delay irksome and tedious, not to mention the expense involved.

For a long time in our reconstructive work, we have felt that such flaps were left attached unnecessarily long. No one would intentionally hazard the safety of flap tissue by taking a chance on cutting down the time necessary for an adequate take. On the other hand, we have become more and more convinced that definite tests were possible for determining the adequacy of the circulation at the end of such a flap and that these tests could be relied upon within very close limits of error.

The bearing of the reduction of time and discomfort upon the choice of reconstruction methods as well as upon the economy to all concerned needs no further elaboration.

Recently, one of us succeeded in shifting a flap successfully from the abdomen to the wrist in nine days (Fig. 1). In this patient's case three shifts were accomplished in a total of 35 days, without loss of tissue.

FIG. 1.—Pedicle tube flap, shifted at brief intervals from abdomen to wrist to orbit.

Previous to this, like most workers in this field, we had depended upon clinical reports in making up our minds as to the proper time to shift the pedicles of flaps.

Fomon's text[3] gives the opinions of many authors on this point of the earliest safe time at which to shift a flap. One author advises "cutting the pedicle 10–14 days after operation." Another says simply: "Reconstruction by means of tubed flaps are carried out in stages at intervals of three

weeks." Another in speaking of the second stage or cutting the distal pedicle says: "This may be done as soon as collateral circulation has been established in the flap, a process which usually requires three weeks." Another reference speaks of division of the donor pedicle in three weeks and its attachment to the new defect, and, finally, another speaks of the severance of the pedicle still attached to the original donor site in about "three weeks."

We were confirmed in our feeling that flaps are left attached unnecessarily long by the work of German, Finesilver, and Davis.[4]

Briefly, they stated that different authors advised that from several weeks to as many months elapse before dividing one pedicle and making the transfer, but that they felt that while this long delay was never disadvantageous as far as the circulation is concerned it is actually unnecessary.

In order to find out how soon the circulation in pedicle tube flaps becomes established after their formation on the abdomen of dogs they used the following methods:

1. They divided one end of the flaps after an intravenous injection of toluidine blue, and as soon as the dye was seen to come through the cut end of the flap, fixed and opened it at the suture line and cleared it for study of the vessels.

2. Barium in gelatin was injected in the aorta and after the same division roentgenograms were taken to visualize the vessels without opening the flaps.

3. They studied sections of the flaps in the first series, histologically, by staining with hematoxylin–eosin.

The flaps in all three series were divided for study after varying periods of time subsequent to their formation.

They found that flaps immediately removed after their formation showed a few blood-filled vessels crossing at right angles to the long axis of the flap.

At 24 hours a few vessels could be seen running almost the entire length of the flaps and, in general, the arrangement of vessels was more definite.

At four days this arrangement of vessels was more definite.

At seven days the vessels were found to be numerous and to run the entire length of the flap.

At 14 days they found very little difference from the findings of the seven-day specimens in the number, character, arrangement, or size of the vessels.

From their experiments these authors conclude that an adequate blood supply in tubed pedicle flaps is established from a single pedicle within seven days, and that the development of this adequate blood supply appeared to be dependent on three factors:

1. An increase in the size of the vessels.

2. An increase in the number of functioning vessels.

3. A reorientation of the main vascular channels corresponding to the long axis of the flap.

It was their feeling that these same facts would hold for human skin

flaps, as they do for those of dogs, and they showed a human case in which the division of a short pedicle flap from the arm to the cheek was begun on the tenth day and completed on the eleventh day, without loss of tissue.

The work of these authors is excellent in quality and gives one an interesting and valuable picture of the rearrangement of blood vessels which takes place in a tubed flap at different stages, but we do not feel that on grounds purely histologic, they are justified in concluding, without actually transferring the ends of their flaps, that a seven-day period is sufficient for the development of a blood supply adequate for the transfer of one end, nor do we feel that their implication that the earliest time for safely beginning the transfer of the ends of tubed skin flaps in humans is probably the seventh or eighth day is necessarily justified on the basis of dog experiments alone. In dogs many factors which influence healing may differ from those in humans. For example, in dogs the normal basal metabolic rate per unit body surface is higher than in humans.

During the past two years we have sought on physiologic grounds to study the development of the circulation in tubed skin flaps in dogs and in humans with a view to the establishment of a test or tests for the accurate quantitative study of circulatory adequacy and, hence, to the determination of an optimum time for transfer of one end of the flap to a new location. Only through such means do we feel that an early transfer can be safely made.

EXPERIMENTAL STUDIES

For convenience our experiments are divided into four types, in all of which the same kinds of tube pedicle flaps were used.

Formation of Flaps.—Dogs weighing between 7 and 12 Kg. were used. The abdomen and anterior and lateral thorax were shaved. Employing nembutal anesthesia, two straight parallel incisions were made longitudinally, which extended approximately from a point three inches from the end of the anterior axillary fold to one or two inches superior to the fold of the groin. The skin and subcutaneous fat down to the superficial fascia were undermined and lifted between these incisions, and the edges of the skin so lifted were approximated with a single layer of sutures to form a tube flap. The ends were left attached to their beds, respectively. The two raw edges of abdominal skin remaining were undermined by spreading scissor points apart at the same depth. They were then approximated by a row of silk sutures in the subcutaneous tissue and another through the skin edges. The tube flaps so formed resembled a suitcase handle and their circumference was one-fourth to one-fifth as great as their length.

SERIES I—BLOOD PRESSURE EXPERIMENTS

The purpose of the several experiments in this series was to determine the systolic blood pressure present in the pedicle of the flaps at different intervals after their formation.

Method: Miniature blood pressure cuffs were employed. The first type consisted of an inflatable tube of thin rubber Penrose drain materials sealed at one end and joined to a rubber connecting tube at the other. This tube was covered with an oiled silk jacket. This cuff was wrapped around the pedicle at one end and joined to a rubber connecting tube at the other. Thus the tourniquet was applied at one end of the flap as one would wrap an ordinary blood pressure cuff on the arm. Over it was bent a small aluminum collar, split at one point to allow the sleeve to come through it. An ordinary mercury manometer calibrated in millimeters was connected to the collar and the usual type of hand pressure bulb was employed to sustain and test pressure. A change in temperature in the flap was used as the criterion for judging the point at which the pressure of the tourniquet was overcome by the systolic blood pressure within the pedicle tested. The apparatus of Brooks,[5] described in 1925, for measuring temperatures in the extremities was employed. This consists of a thermo-couple mounted in a hypodermic needle and a galvanometer. The temperature change in the pedicle flaps registers very readily, just as is the case in human extremities.

Description of Procedures: With the pressure cuff applied loosely at one end and a firm rubber band to stop all blood flow at the other, the thermocouple needle is introduced into the distal end of the flap and the blood is pressed out of the tube-flap and the air pressure immediately raised to 200 millimeters of mercury (See Fig. 2).

The flap is allowed to cool for ten minutes or more and definite readings of the temperature are obtained. The pressure within the tourniquet is then lowered ten millimeters at a time until the temperature in the flap begins again to rise. This point is considered to be the effective systolic blood pressure.

In the case of some of the double pedicled flaps a blood pressure cuff was placed on each end and the two were connected by a "Y" tube to a common manometer creating a system similar to a Lockheed hydraulic automobile brake. By this means simultaneous average pressures could be obtained for the two ends.

Single Pedicled Flaps: In several experiments determinations were made on flaps, one end of which had been left attached after amputation and closure of the other. On some of these the pressures were checked by watching the arterial bleeding stop as the measurable pressure on the tourniquet was increased.

Results: Our findings in these tests are given in the accompanying Table (Fig. 3).

Conclusions.—These findings appear to justify the following conclusions:

1. In double pedicled tube flaps with one end totally occluded the blood pressure registered at the open pedicle gradually increases with the age of the flap. At 48 hours it is about 25 per cent of the normal systolic femoral

BLOOD PRESSURE IN PEDICLE FLAPS

1. Double Pedicled Tube Flaps.

Apparatus	Dog No.	Days after formation	Systolic B.P m.m. Hg.	B.P. Femoral artery	Diagram of flaps
Single cuff tourniquets. Other end occluded	65	2	25-20		
	65	12	90-80	117	
	65	60	100-90*		*Checked by division of one end and watching cessation of active bleeding
	68	14	60-40		
	39	33	110-100		
	61	42	120	170-165	
Double cuff: One at each end with common connection to manometer	65	30	65		
	68	14	60-50		

2. Single Pedicled Flaps.

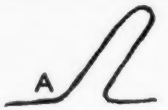
Single cuff Tourniquet	65 1st Flap	60	110-105	115-117	
			2 days later 115	120	
	65 2nd Flap	60	100-90	120	

FIG. 3.

pressure, at two weeks it is about 60 per cent, and one month 90 to 95 per cent.

2. Employing tourniquets on both pedicles coupled in a single system, pressure figures are consistently lower on the same dates than the figures for a single tourniquet on a single pedicle. This seems to us to indicate that the pressure within the vessels of the flap must diminish from one end to the other no matter in which direction the blood flows. Consequently

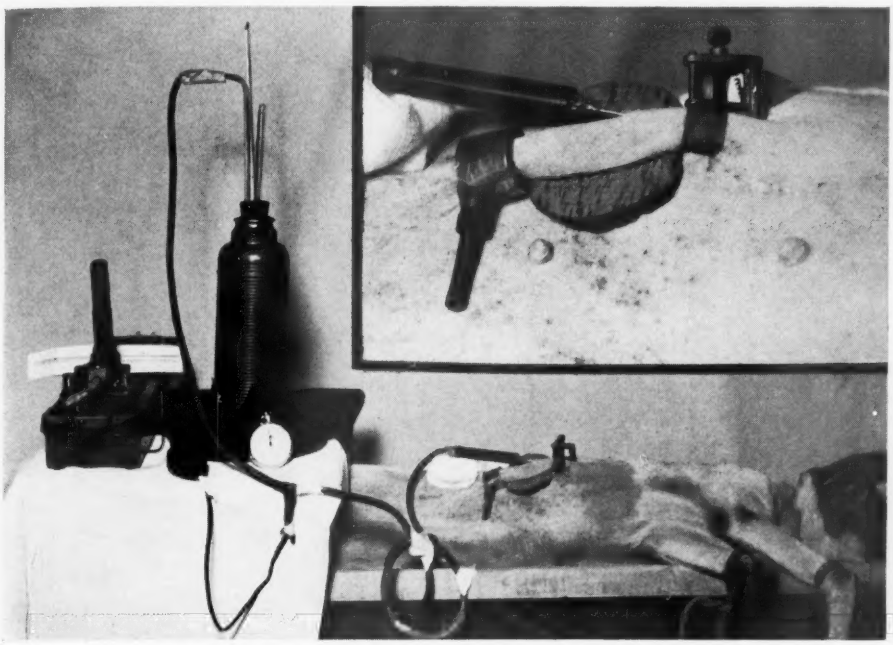


FIG. 2.—Thermocouple temperature-testing apparatus applied to pedicle flap. Needle inserted. Pressure cuffs at ends. Insert: Close-up view of flap.

even if pressure at one end was high, *e.g.*, 100 millimeters of mercury, blood flow could not occur on account of back pressure until the tourniquet pressure was reduced to a much lower point at the other end.

3. In single pedicled tube flaps pressures reach 95 per cent of normal-femoral levels after two months.

SERIES II—HAIR GROWTH EXPERIMENTS

It was thought that growth of hair on the flaps might indicate the total effect over a period of days of the primary retardation and gradual re-establishment of circulation in them.

Several flaps were formed in the usual manner after shaving. Their length was roughly three and one-half times their width or three and one-half times the circumference of the tubes. Under a magnifying binocular loupe the lengths of hairs were easily measured at varying intervals following operation. Three levels were chosen for these estimations, the upper, middle

and lower portions of the skin of the flaps and the skin on each side adjacent to that of which the flaps were formed. Ten determinations were made at each site. Results of measurements are shown in Figure 4.

Figures up to six days show only slight differences in the rates of growth

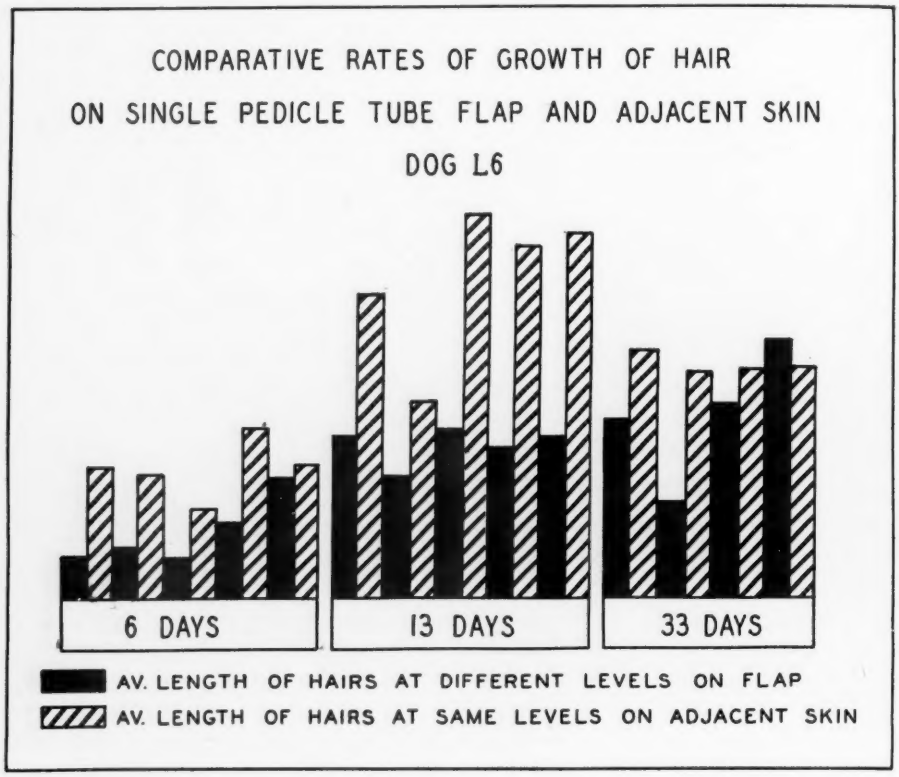

COMPARATIVE RATES OF GROWTH OF HAIR
ON SINGLE PEDICLE TUBE FLAP AND ADJACENT SKIN
DOG L6
6 DAYS
13 DAYS
33 DAYS
AV. LENGTH OF HAIRS AT DIFFERENT LEVELS ON FLAP
AV. LENGTH OF HAIRS AT SAME LEVELS ON ADJACENT SKIN

FIG. 4.

on flap and corresponding abdominal skin origin, the edges of which have been undermined and sutured under slight tension.

Dog 61: Determinations on a single pedicle flap formed by division of one end of a double flap (made 23 days before) show that between the seventh and tenth days there are marked differences in growth rates at points on the flap and the corresponding abdominal skin. The hair on the flap is only 68 per cent as long as that on the abdomen.

Dog L. 6: Single pedicle. Lower end attached by strand of tissue. Definite differences after six days. Average length of hair in flap is 72 per cent of that of the adjacent abdominal skin. Also, after 13 days it is 56 per cent and after 33 days it is 78 per cent of that of the adjacent skin.

Conclusions.—From our records we conclude that the growth of hair on double pedicle flaps recently formed is only slightly retarded in comparison with that on adjacent points on the abdominal skin from which the flaps are formed. Likewise, our results on single pedicle tube flaps show that the growth of hair on a blind ended flap is definitely retarded during the first and second six-day periods and that after a month the rate of growth is still somewhat retarded in comparison to that of the hair on the adjacent skin.

SERIES III—TEMPERATURE-RETURN EXPERIMENTS
THE TEMPERATURE-RETURN TEST

In these experiments flaps similar to those employed in previous determinations were employed but, in addition, readings were taken on two human pedicle flaps before transfer of one of the ends.

In most cases, without anesthesia, a fixed tourniquet consisting of a band of thin Penrose rubber drain material was wrapped tightly enough around one end to entirely shut off the circulation, then the blood was expressed by compression of the flap between the fingers and a second tourniquet applied at the other end. In a few this expression of blood was omitted. In all thermocouple needle temperatures were taken in the abdominal subcutaneous tissue and in the flap before tourniquets were applied and the needle point was left in the subcutaneous tissue of the flap for subsequent temperature readings, which were made at one minute intervals. After a cooling period, which lasted from 10–15 minutes, the tourniquet at the end away from the needle point was released and the return of temperature recorded over periods varying between 5 and 15 minutes, depending upon the indications. Ordinarily there is a slight initial temperature rise before application of the tourniquet, probably due to a vasodilatation caused by the insertion of the needle, followed by a fall in temperature of from three to six degrees, depending upon the dog's temperature and that of the room. The extent and rate of the rise in temperature which occurs when the tourniquet is removed from either end with the needle in the center or the other end of the flap is taken to indicate the efficiency of the circulation through the flap. A thin cork-guard between the dog's body and the flap prevent the flap from being heated from the body. A pneumatic cuff tourniquet was used in some of these flaps and on others two sharpened fine steel wires transfixed the end of the flap at right angles to each other, so that the vessels of any quadrant or quadrants of the flap could be closed by crossing and making traction on the wires. In all, about 30 experiments were carried out in this series, of which a few of the more typical examples will be discussed in detail. Two of the determinations were on human flaps (See Series IV).

Dog. 28: Figure 5 gives one an accurate picture of the return of the normal temperature in a flap which was formed two weeks before this determination. It is seen that after an initial rise of about 1° C. a fall of 4.1° C. occurred when both ends were completely occluded for ten minutes. On release of one tourniquet the temperature rises to normal in about six minutes showing an excellent circulation to be present at two weeks.

Dog 67: Figure 6 shows resulting graphs of temperature test on pedicle flaps that have been formed for three and seven days, respectively. In the three-day-old pedicle the latent period in the rise of temperature curve and the delayed ascent of the curve are indicative of inadequate blood flow in the flap for the maintenance of viability. However, in the pedicle that has been formed seven days there is an immediate rise in temperature after removal of the tourniquet.

Dog 61 (Figure 7): In this experiment a 107-days-old flap was transfixed at one end by fine sharp pointed wires dividing it into quadrants. When blood was allowed through one quadrant no rise occurred. When two quadrants, or one-half of the flap was open, a slow rise occurred, *viz.*, about 0.6° C. in five minutes, whereas the rate increased markedly when all pressure was removed.

Dog 10 (Figure 8): In this and other experiments a series of determinations were made on a single flap as it aged at one hour, three and one-half hours, 72 hours, and six days. There is a lag in the return of circulation through the lower end until the sixth day, at which time it is excellent.

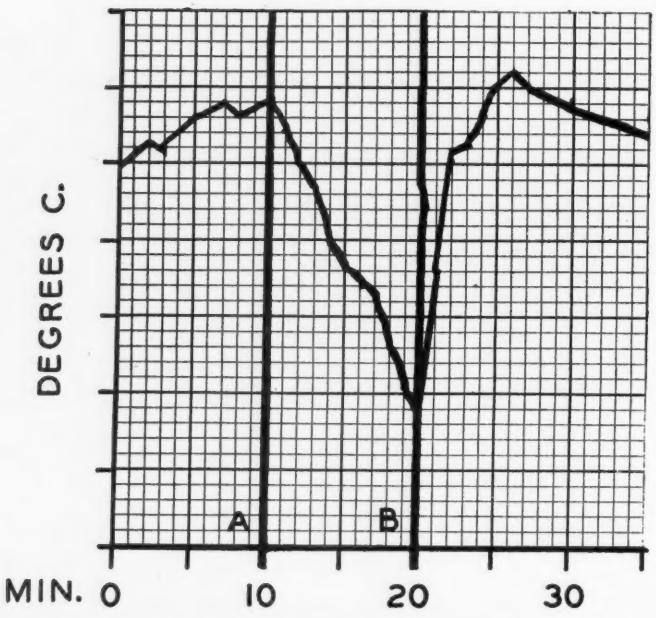


FIG. 5.—Normal temperature curve on pedicle flap. Dog 28—2 weeks postoperative. A—Both tourniquets on. B—Both tourniquets off.

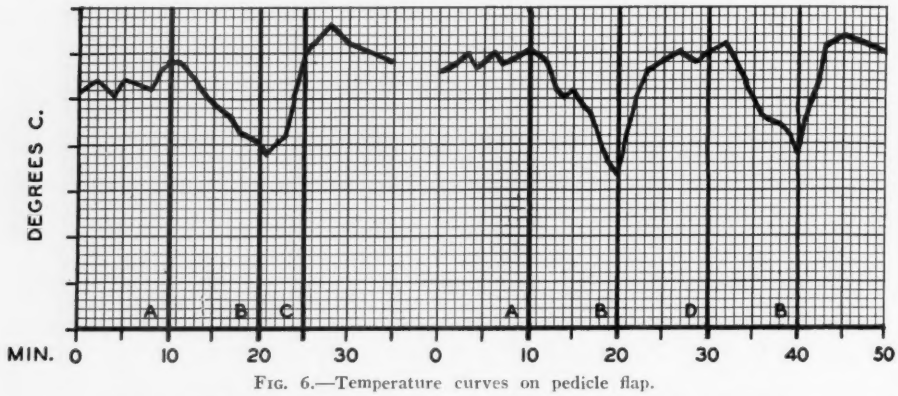


FIG. 6.—Temperature curves on pedicle flap.

Dog 67—Three days postoperative.
A—Both tourniquets on.
B—Lower tourniquet off.
C—Upper tourniquet off.

Dog 67—Seven days postoperative.
A—Upper tourniquet on.
B—Upper tourniquet off.
D—Lower tourniquet on.
B—Lower tourniquet off.

Conclusions.—1. Employing the Brooks' thermocouple technic to pedicle flaps normal temperature return curves were established for pedicle flaps which had been formed for periods of time over two weeks.

2. Flaps tested earlier show a progressive increase in circulatory efficiency. Sluggish at one hour, it is slightly better at three and one-half hours, and by the sixth to the seventh day is excellent.

3. Infection seems to retard the return of temperature. This subject needs further study.

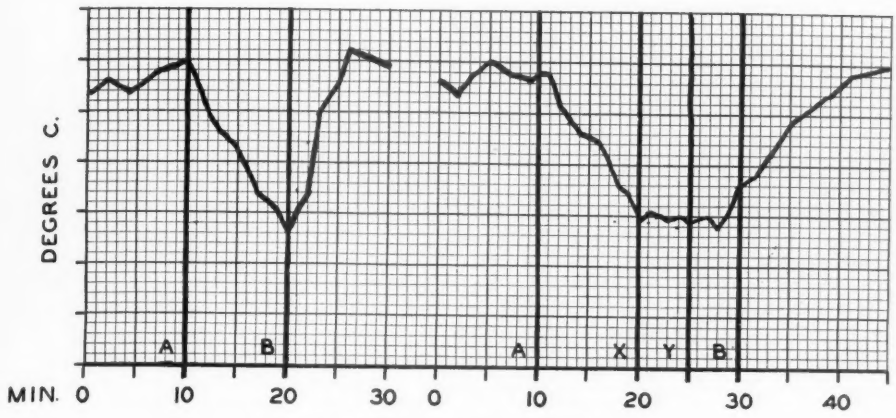


FIG. 7.—Temperature curves on pedicle flap.

Dog 61—Normal curve.
A—Tourniquet on.
B—Tourniquet off.

Dog 61—Selective circulation by quadrants.
A—Tourniquet on.
X—One-quarter pedicle open.
Y—One-half pedicle open.
B—Tourniquet off.

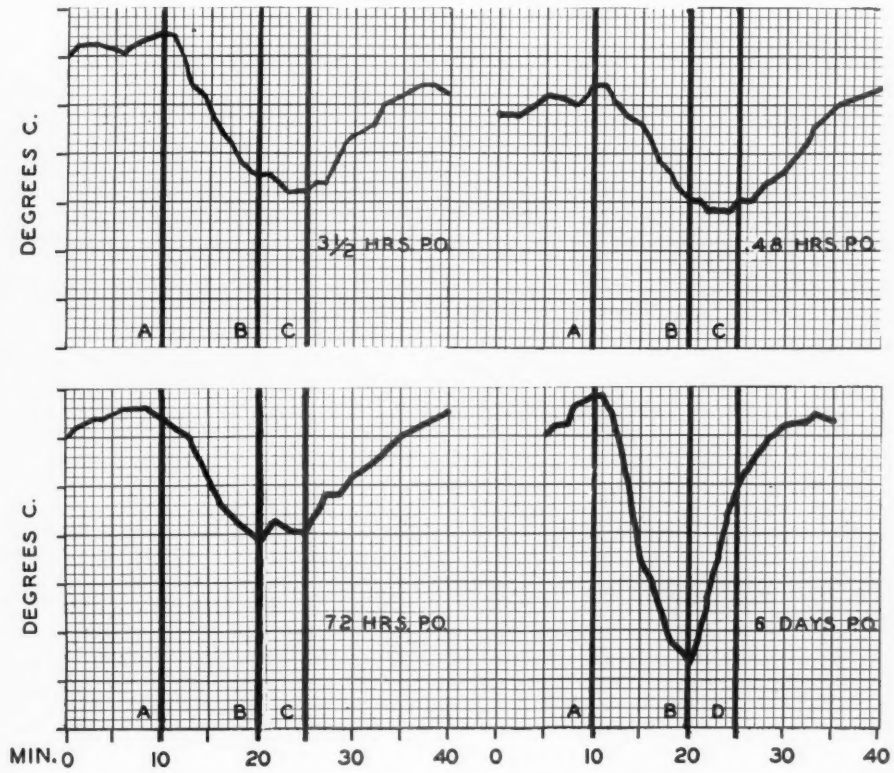


FIG. 8.—Temperature curves on pedicle flap at various postoperative intervals.

A—Both tourniquets on.
B—Lower tourniquet off.
C—Upper tourniquet off.

A—Both tourniquets on.
B—Lower tourniquet off.
D—Both tourniquets off.

4. When a special tourniquet is applied to a flap by quadrants of the tube the efficiency of the circulation appears to be affected in direct ratio to the number of quadrants occluded.

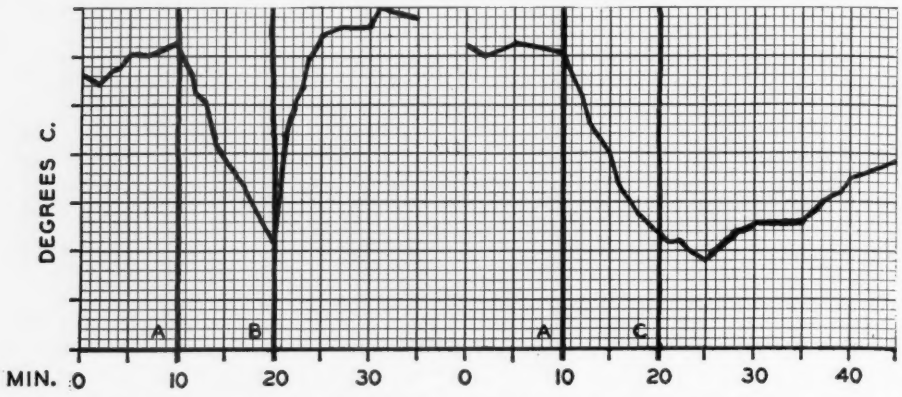


FIG. 9.—Temperature curves on pedicle flap. A—Both tourniquets on. B—Upper tourniquet off. A—Both tourniquets on. C—Lower tourniquet off.

SERIES IV—EXPERIMENTS ON SURVIVAL AFTER TRANSPLANTATION AT VARYING TIME INTERVALS

The purpose of this series of experiments was to determine the earliest safe times after formation of pedicle flaps, in dogs and humans, at which first one end and then the other may be shifted to other sites without jeopardizing the complete viability of the flap. Obviously, in general, the greater the lengths of the flaps in proportion to their widths the less safely can transfers be made, but since all of our flaps were three to five times as long as broad there is little variation in this respect.

We feel that it is fundamentally important to find out in how short a time a whole flap, *i.e.*, both ends may be safely shifted in two stages, one end at a stage, since during this procedure not only must the vessels derive new vascular connections at both ends but the pressure must be sufficient to establish a circulation throughout the entire length of the flap while it is entirely "parasitic," if we may use this word in a topographic or locational sense only. Although this series is not yet completed several studies have already been made of which the following are typical:

Dog 67: Pedicle flap of abdomen had been formed for ten months. Circulation in one end tested with thermocouple needle and found to be good (Fig. 9). Five days later, when temperature curve showed sluggish circulation through the transplanted end, the opposite end was transplanted. The latter end became gangrenous and pulled away from its attachment four days after the second operation.

Dog 14: This dog had had his flap made a year before. After testing, one end was replanted or shifted on 1-26-42. A test on 2-2-42, or nine days after the former shift, showed adequate circulation through the transplanted end. The opposite end was next shifted. Except for a small spot of ulceration at the outer angle of the suture line and a superficial one on the outer surface of the flap, both of which were negligible, the entire flap survived. A test seven days later showed very adequate circulation through both ends.

Human Determinations.—Three humans upon whom pedicle flaps were made during facial reconstructions had the circulation in their flaps studied.

Case No. 1.—J. B., male, age 12. Exenteration of orbit, 1-6-40, for cavernous hemangioma of conjunctiva. Repair of the granulating wound of the orbit was effected by a tube pedicle flap which was first lifted from the abdomen then sutured to the wrist after nine days and, in turn, to the orbital wound edges. Following severance of the distal pedicle, 12 days later a tube of skin and subcutaneous tissue remained attached to the wrist (see Fig. 1).

Several blood pressure determinations were made between the date of severance of the distal pedicle, 2-29-40 and the date of the excision of the flap. These were made by an inflatable ring-cuff slipped over the tube and a water-jacket over its distal end to register volume changes.

Results: 3-14-40 systolic B.P. 30–25 mm. mercury
4- 2-40 systolic B.P. 28–25 mm. (3 readings)
5- 7-40 systolic B.P. 55–25 mm. (3 readings)
5-7-40 systolic blood pressure determined at brachial, 105/98.

Case No. 2.—J. T., male, age 36. During the course of reconstruction of the right cheek and right angle of the mouth a tube was formed from the shoulder to the right cervical region. The return of temperature was tested by the thermocouple needle on 3-20-41, 20 days after the previous shift. It was thought best not to apply tourniquet very tightly. The temperature did not fall markedly, and the rise in temperature afterward, of 25 per cent, was not very significant. The outer end of the flap was shifted the next day and the flap remained entirely viable.

Case No. 3.—L. McD., female, age 19. In course of reconstruction of a portion of the lip and nostril a tube flap of abdominal skin was left attached between these two parts. Determinations of the return of temperature when the tourniquet was released from each end in turn were made on the twenty-fourth day after the nasal end was attached (Fig. 10). These showed a good circulation through both pedicles (Fig. 11). Accordingly the lip end was divided and reimplanted on the cheek the next day. Healing in the new area was uneventful with complete survival.

Conclusions.—1. A single pedicled tube flap on the wrist of a boy, age 12, whose brachial blood pressure was 105/98, showed a pressure of 30 after two weeks, 28 after a month, and 55 after two months.

2. In two adult patients upon whose double pedicle flaps temperature-return curves were made by the thermocouple method, the circulation was demonstrated to be adequate, and actual transfer proved this to be the case since both healed without tissue loss.

3. In a boy, aged 12, three shifts of tissue in a tube flap were made in a total of 35 days, an average of 11.2 days per stage.

4. Transplantation in five days of the opposite end of a flap, the pedicle of which, by thermocouple temperature, showed an inadequate circulation, resulted in gangrene and detachment.

5. Transplantation after seven days of the end of a flap, the pedicle of which, by thermocouple temperature test, showed an adequate circulation proved successful. Both ends of the flap showed adequate tests after seven days.

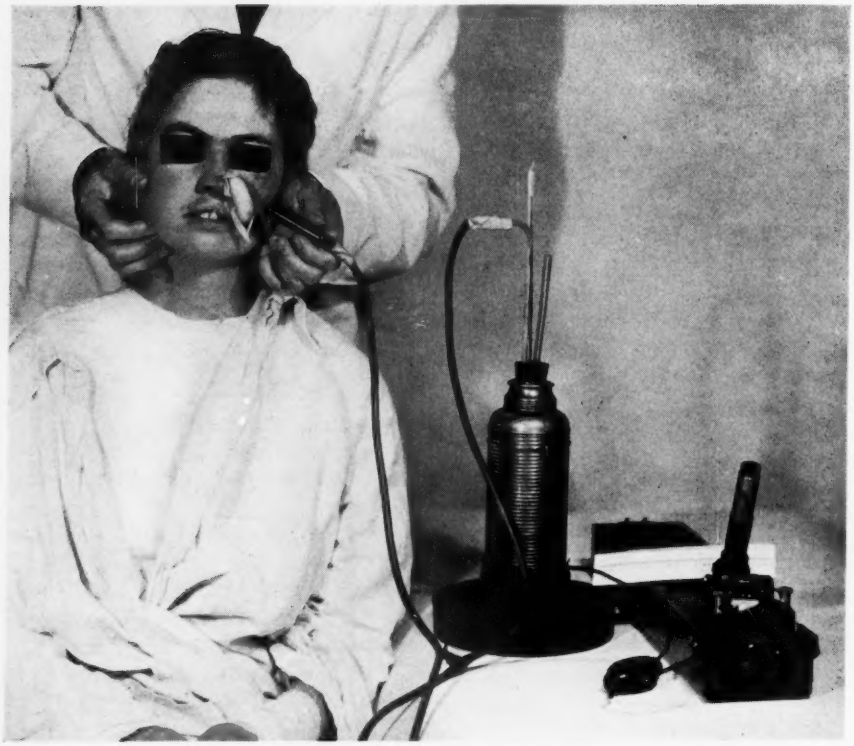


FIG. 10.—Efficiency of circulation through each pedicle of human flap determined by "temperature-return test." Needle inserted; tourniquets applied.

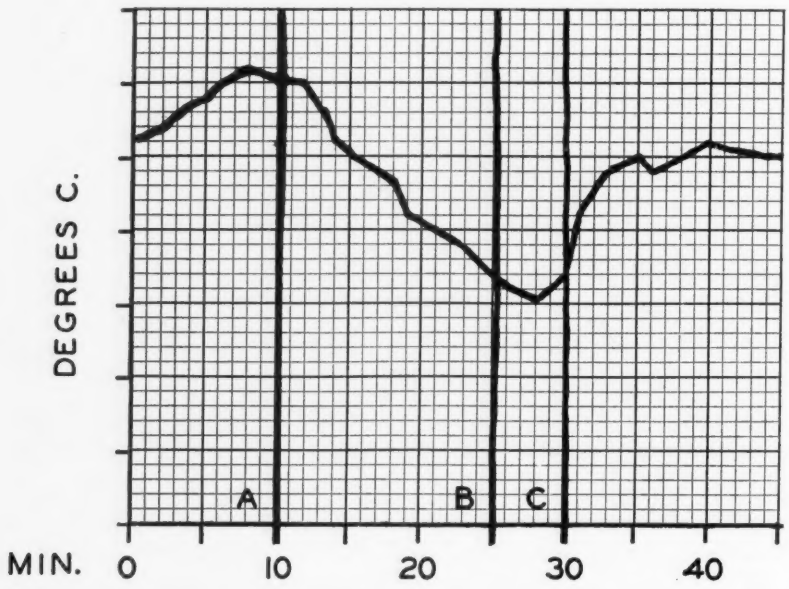


FIG. 11.—Temperature curve on human pedicle flap. Patient L. M. 24 days post-operative. A—Both tourniquets on. B—Lip end off. C—Nose end off.

SUMMARY OF RESULTS

The efficiency of the circulation of double and single pedicle tube flaps in dogs, by which is meant the ability of the vessels to function in such a way as to maintain tissue viability at the other end, was studied by means of four physiologic or functional tests, *i.e.*: (1) Measurement of blood pressure; (2) growth of hair; (3) rate of return of temperature after constriction; and (4) viability or ability to survive after surgical transfer.

1. By employing specially designed miniature cuffs and thermocouple needles in the flaps, their pressures were measured and found to increase with the time interval after their formation, until, at two months, they were 90 to 95 per cent of normal femoral pressure. In a single-ended pedicled human flap the pressure reached 50 per cent normal brachial blood pressure in two months.

2. Hair growth was found to be moderately retarded for 12 days on pedicle flaps in comparison to the growth on the adjacent skin.

3. The rate of temperature return following release of a tourniquet, constriction of which had caused cooling of a flap, was found to be inversely in ratio to the proportion of the pedicle constricted at the end of the flap. This rate was also slow, one hour after the flap was formed, and gradually increased until it almost reached a maximum at six days.

4. Using this temperature return test as a criterion of the adequacy of circulation through the entire flap, the actual ability of several flaps to withstand transplantation was tested by surgically transferring their ends, and practical correlations were obtained between the test and result of transfer both on dogs and on humans.

Discussion.—On anatomic grounds, German, Finesilver and Davis[4] concluded that the blood vessels in pedicle flaps in dogs was well developed in seven days, running from one end of the flap to the other, and that from that time through the fourteenth day there was little change in the number, character or size of the vessels. None of their pedicle flaps on dogs was shifted to see whether its vessels were actually sufficient to support the life of the flap. Davis and Traut,[2] in 1925, also showed that the orientation of vessels was important even in small skin grafts.

While agreeing, in general, with their conclusions we felt that physiologic criteria are better than anatomic ones in determining circulatory efficiency. Hence, our work with flaps, along functional lines, has led to development of definite tests.

We would urge any surgeon to exercise caution in judging the circulation of pedicle flaps so as not to transplant the ends too soon. It is wise, of course, not to hazard the life of flap tissue by too great haste. Nevertheless, we feel that with the means which we have established of accurately judging the circulatory condition on each individual and from either end of a flap, much valuable time and expense may be saved and much discomfort safely avoided for the patient. In war time this is of especial importance.

To give an example in the very first tested case (a boy, age 12), we have been able to transfer skin from the abdomen *via* the wrist to the orbit in a total of 35 days, an average of 11⅔ days per stage. One of the intervals was nine days. In none was partial division of the pedicle practiced, as advocated by German, and his coworkers. If we followed ordinary textbook rules, this transfer would have taken 55 to 63 days, at the very minimum. By following indications of the findings afforded us by the "temperature-return test" as we call it, we have been able to transfer successfully, on a dog, an entire flap of skin eight inches long, so that both ends were reattached in new beds in a period of nine days. More recently, we have succeeded in transferring

FIG. 12.—Rapid transfer of tissue in pedicle flap on dog. Upper end shifted seven days after transplanting lower end. Thermocouple test showed adequate circulation before each shift. No loss of flap tissue occurred.

a flap one and three-fourths by seven inches, on a dog, from one location to another, the two ends being shifted seven days apart, without the slightest ulceration or tissue loss (Fig. 12).

In these two experiments, before transfer of the ends, the "temperature-return test" showed an adequate flow of blood. It is interesting to note that these flaps must be thought of as "autoparasites" since all of their tissue was completely shifted in such short times. Since the vessels in the second were obviously connected, and the blood flowing freely from one end to another in the brief period of seven days, it is probable that the vessels connected up before the process of fibroplasia of the tissues was complete. It

is, therefore, probable at least that the entire flap, although fully alive, could have been pulled away from the dog's abdomen with very little force.

Failure resulted in the case of another flap in which an attempt was made to transfer the second end five days after the first when the "temperature-return test" had indicated the circulation to be inadequate.

The earliest time established in dogs for successful transfer of a second end of a pedicle flap after transfer of the first is thus shown to be seven days, and somewhat longer in humans. With more experiments and material we hope through "temperature-return test" to reduce this to a definite point for both.

CONCLUSIONS

1. New methods are described for determining the systolic blood pressure in double and single pedicled tube flaps of skin and subcutaneous tissue.

2. Blood pressures were found to be low shortly after formation of the flaps and gradually to increase with the passage of time until at two weeks they approached normal systolic brachial pressures.

3. The growth of hair is moderately retarded on pedicle flaps up to three weeks after their formation which seems to indicate a temporary slight disturbance of the circulation.

4. Applying the Brooks' thermocouple apparatus a test called the "temperature-return test" has been developed for determining the efficiency of circulation in tubed flaps which indicates an increasing circulatory efficiency from the time of the formation of the flap until the sixth or seventh day in dogs, at which time the circulation through either pedicle to the other end appears to reach almost a maximum efficiency. At this time safe transfer of a pedicle may be accomplished.

5. In dogs and humans, curves indicating the efficiency of blood circulation in flaps have been correlated with the ability of the flap to completely survive surgical transplantation.

6. Evidence accumulated from a number of human cases appears to indicate the advantages of this physiologic test in individualizing the circulatory efficiency of the flap so as to save time, with safety, between stages, and to avoid discomfort for the patient incident to well meant but unnecessary delays. In war surgery the importance of this point is obvious.

7. The magnitude of the time-saving is to be determined as further cases accumulate.

REFERENCES

[1] Goodpasture, E. W., Douglas, B., and Anderson, K.: A Study of Human Skin Grafted Upon the Chorio-Allantosis of Chick Embryos. Jour. Exp. Med., **68**, 891, 1938.

[2] Davis, J. S., and Traut, H. F.: Origin and Development of Blood Supply of Whole Thickness Grafts. ANNALS OF SURGERY, **82**, 871, 1925.

[3] Fomon, S. S.: Williams and Wilkins Co., Baltimore, 1939, pp. 230–231.

[4] German, W., Finesilver, E. M., and Davis, J. S.: Arch. Surg., **28**, 27, 1933.

[5] Brooks, Barney: New Methods for Study of Diseases of the Circulation of Extremities. Jour. Bone & Joint Surg., **7**, 316, 1925.

PERFORATED PEPTIC ULCER*

FRANCIS X. TIMONEY, M.D.

NEW YORK, N. Y.

FROM ST. VINCENT'S HOSPITAL, FIRST AND SECOND SURGICAL DIVISIONS, GEORGE R. STUART, DIRECTOR, 1ST SURGICAL DIVISION; RAYMOND P. SULLIVAN, M.D., DIRECTOR, 2ND SURGICAL DIVISION; NEW YORK, N. Y.

THE SUBJECT of perforated peptic ulcer merits discussion. The condition is prevalent in hospitals that have busy emergency services, of which St. Vincent's Hospital is an example. The high mortality reported by various authors throughout the country attest to the seriousness of this condition. Because of this, the cases occurring at St. Vincent's Hospital within the past eight years have been studied. Most of these cases have been operated upon by the younger members of the Attending Staff and by House and Resident Surgeons under their supervision. Two hundred fifty-four cases have been studied. In studying the charts of these patients observations of interest were made. Four patients perforated on the ward while undergoing medical treatment for ulcer. Another patient perforated in a physician's office while undergoing a gastric lavage. Several perforated while carrying a heavy load or doing strenuous work. This is in accordance with observations made by McCreery.[9] Others perforated while drinking beer or highballs.

The accuracy of the clinical diagnosis of perforated peptic ulcer is high, as shown by the following statement: Diagnosis: Correct in 238 operated cases; incorrect in eight operated cases; incorrect in two cases, proved by autopsy.

The following is a list of the incorrectly diagnosed cases:

1. Bleeding ulcer—autopsy showed unrecognized peritonitis due to ruptured ulcer.
2. Acute appendicitis.
3. Acute appendicitis.
4. Acute appendicitis.
5. Acute appendicitis.
6. Acute appendicitis—died 12 days postoperatively of hemorrhage from ulcer which had ruptured.
7. Acute hemorrhagic pancreatitis—no operation performed due to extreme secondary shock. Autopsy revealed generalized peritonitis due to ruptured duodenal ulcer.
8. Acute cholecystitis—At operation, chronically inflamed gallbladder was removed and perforated ulcer repaired.
9. Strangulated hernia.
10. Patient perforated twice, and gastric perforation was repaired each time. At time of second perforation, biopsy from ulcer showed inflammatory

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tissue. One year after second operation, patient was readmitted to hospital with gastric hemorrhage. Died soon after. Autopsy revealed gastric cancer. We believe that ulcer was carcinomatous from the beginning.

Percentage of error—4.2 per cent.

Diagnosis was correct in 238 out of a total of 248 cases, either operated upon or proven by autopsy. The percentage of error is only 4.2 per cent. This high degree of accuracy in clinical diagnosis is attributable to the fact that this type of case is seen regularly by members of the Attending and Resident Staffs. Also, many of the surgeons are on the Staffs of other city hospitals, with busy emergency services, thereby widening their experience with this condition.

One hundred twenty-six cases were described as perforated gastric ulcers; 116 as duodenal ulcers; and two as marginal ulcers.

At times, difficulty was experienced by the operator in determining the site of the ulcer. Several were diagnosed as perforated gastric ulcers, only to have autopsy reveal the location as duodenal. The opposite has also held true, where a surgeon of wide experience diagnosed a "large duodenal perforation" only to have autopsy reveal that the perforation was gastric.

Sex Incidence.—The disease is seen predominately in men—male, 246 cases; female, 8 cases.

Roentgenologic examinations for air or gas under the diaphragm have been of limited value in the cases studied: Positive for air under diaphragm 93 cases; negative for air under diaphragm 83 cases; total of 176 cases.

By history and physical examination, experienced clinicians diagnose perforated ulcers more accurately than by roentgenologic examination. The routine taking of roentgenograms, that will delay operation in cases already diagnosed clinically, might better be abolished.[10] We believe roentgenologic studies to be of most value in the occasional case where the clinical picture is not definite.

Mortality.—The following table shows our total and operative mortality:

TABLE I

Total number of cases	254
Total mortality	48
Total operated upon	246
Operative mortality	19.5%

This mortality compares favorably with that reported in recent years from various sections of this country and England, which averages around 20 per cent (See table II).

The notable exception is that of Graham,[7] who reports the strikingly low mortality of only one death in 51 operated cases. This is all the more remarkable because his report covered the years 1929 to 1935, a period when Wangensteen suction was not generally used, and only at the end of this period was sulfanilamide first brought to our attention. Graham graciously acknowledges the early correct diagnosis and the speed with which the family physicians of Toronto referred the patients to the hospital.

TABLE II

MORTALITY STATISTICS

Author	Total Cases	Mortality
Berson, H. L.	151	15.2%
Davidson, T. C., and Rudder, F. F.	155	28%
DeBakey, M., and Odum, C. B.	211	17.3%
Donald, D. C., and Barkett, S. M.	116	18.5%
Eliason, E. L., and Thigpen, G. M.	70	21.43%
Fallis, L. S.	100	20%
Years 1917-26—62.5%		
Years 1926-36—11.9%		
Graham, R. R.	51	1.96%
McCreery, J. A.	170	20.5%
Martz, H., and Foote, M. H.	50	26%
Parker, E. F.	52	27%
Marshall, S. F., and Keleher, P. C.	46	13%
O'Donoghue, J. B., and Jacobs, M. B.	200	24.5%
Read, J. C.	100	30%
Ross, A., and Letourneau, C.	220	17.7%
Ross, J. C.	175	16%
Sangster, A. H.	100	23%
Thompson, H. L.	424	28.7%

Nevertheless, Graham sets an example which all should strive to follow. Due to the activity of the ambulance service most patients were brought *early* to hospital.

The tables of total cases and duration of symptoms follow:

HOURS -

To 6 Hours	6-12 Hours	12-24 Hours	Over 24 Hours	Not Stated
158	50	15	17	14
62.2%	19.6%	5.9%	6.6%	

Total cases stated 240
Duration of symptoms not stated 14

Total 254

DURATION OF SYMPTOMS IN 48 FATAL CASES

Under 6 Hours	6-12 Hours	12-24 Hours	Over 24 Hours	Not Stated
17	11	6	6	8
10.8%	22.4%	40%	35%	

We have tried to present the general picture of perforated peptic ulcer as occurring during the past eight years. With the advent of intraperitoneal use of sulfanilamide, we noted improvement and better results in our cases. Our Staff has not changed materially during the last eight years. We felt that the improvement noted in our results might possibly be due to increased knowledge, experience, and technical skill on the part of the Attending Staff. Accordingly, the last 50 consecutive cases, before those in which sulfanilamide has been used, were analysed. These are compared with those in which sulfanilamide was used in the peritoneal cavity. The following tables show the results:

AGES OF 50 RECENT CASES, WITHOUT INTRAPERITONEAL USE OF SULFANILAMIDE

YEARS						
10-20	20-30	30-40	40-50	50-60	60-70	70 plus
	8	17	9	9	7	
	16%	34%	18%	18%	14%	

AGES OF 49 CASES WITH INTRAPERITONEAL USE OF SULFANILAMIDE

YEARS						
10-20	20-30	30-40	40-50	50-60	60-70	70 plus
2	6	11	14	9	5	2
4.08%	12.2%	22.4%	28.5%	18.3%	10.2%	4.08%

DURATION OF SYMPTOMS OF 50 RECENT CASES WITHOUT INTRAPERITONEAL USE OF SULFANILAMIDE

HOURS				
To 6 Hours	6-12 Hours	12-24 Hours	Over 24 Hours	Not Stated
32	10	1	4	3
64%	20%	2%	8%	

RESULTS OF 50 RECENT CASES TREATED WITHOUT SULFANILAMIDE

Total cases.....50
Deaths.....12
Recoveries.....38

DURATION OF SYMPTOMS OF 49 CASES WITH INTRAPERITONEAL USE OF SULFANILAMIDE

HOURS			
To 6 Hours	6-12 Hours	12-24 Hours	Over 24 Hours
26	16	2	5
53.06%	32.6%	4.08%	10.2%

Of these recent 50 cases in which there was no intraperitoneal use of sulfanilamide, 12, or 24 per cent, died. The following is a brief résumé of the fatal cases:

RÉSUMÉ OF FATAL CASES NOT TREATED WITH SULFANILAMIDE

1. Male, age 56, eight hours symptoms, died 12 days postoperatively of intestinal hemorrhage. Had appendicectomy at operation.

2. Male, age 51, seven hours symptoms, died seven days postoperatively of generalized peritonitis. Had gastro-enterostomy.

3. Male, age 38, two and one-half hours symptoms, died two days postoperatively. Autopsy revealed generalized peritonitis.

4. Male, age 49, four and one-half hours symptoms, died three days postoperatively of pulmonary atalectasis.

5. Male, age 67, four and one-half hours symptoms, died seven days postoperatively of bilateral lobar pneumonia.

6. Male, age 59, nine and one-half hours symptoms, died one day postoperatively of pulmonary atalectasis. In very poor condition on admission. Decision to operate is to be questioned.

7. Male, age 53, four and one-half hours symptoms, died three days postoperatively. Autopsy showed generalized peritonitis and a large gastric ulcer.

8. Male, age 52, five and one-half hours symptoms, died 13 days postoperatively. Course was stormy, had lobar pneumonia. No autopsy.

9. Male, age 50, six hours symptoms, died two days postoperatively. Was on Medical Ward undergoing treatment when perforation occurred. Died of postoperative pneumonia.

10. Male, age 58, three hours symptoms, had advanced peritonitis and died on the operating table. Operator believed that perforation must have occurred before the stated time.

11. Male, age 39, four hours symptoms, died three days postoperatively of delirium tremens.

12. Male, age 29, ten hours symptoms, died five days postoperatively of delirium tremens.

In reviewing these 12 postoperative deaths, we see that infection contributed directly to the fatal outcome, in the four cases of death, by generalized peritonitis, and in the five cases of fatal pulmonary complications. Infection might well have been present in the two fatal cases of delirium tremens. We believe that if there had been a local intraperitoneal use of sulfanilamide in the above stated cases, infection would have been controlled, lessened, or prevented.

Unfortunately, this represents a serious group of cases. Eight patients were 50 years of age or over, and two suffered from chronic alcoholism, and finally succumbed from delirium tremens.

We compare this with 49 cases of perforated peptic ulcer, treated consecutively, with the intraperitoneal use of sulfanilamide. In addition, each patient had a small amount of sulfanilamide placed in the wound.

Cases treated with intraperitoneal use of sulfanilamide: Total number, 49. Deaths, 2. Recoveries, 47.

Résumé of fatal cases treated with intraperitoneal use of sulfanilamide:

1. No. 26317, female, duration of symptoms six hours, age 31. W.B.C. 7100, 52 per cent polys. Findings at operation—perforated gastric ulcer, with marked peritoneal reaction. Procedure: Closure and drainage. Died one day after operation. Autopsy showed generalized peritonitis.

2. No. 28423, male, age 63, admitted to hospital with symptoms of abdominal pain and tenderness in R.L.Q., of six hours duration. W.B.C. 6750, 74 per cent polys. Admission diagnosis was "gastro-enteritis" but "patient should be observed for possible acute appendicitis." Twelve hours later, rigidity developed, and diagnosis of ruptured ulcer was made. He was operated upon more than 18 hours after onset of symptoms. Procedure: Closure and drainage. Died on third postoperative day, with chest signs of postoperative pneumonia. No autopsy obtained. In this case an early diagnosis was missed.

Of these 49 cases treated locally with sulfanilamide, 22 were drained and 27 were not drained. From this, we are unable to draw any conclusion as to the effect of drainage when sulfanilamide is used locally.

In the total 246 cases operated upon, wound infections were noted on the charts in 63 instances, an incidence of 25.6 per cent: Total cases operated upon, 246. Wound infections, 63. Incidence of wound infection 25.6 per cent.

In the 49 cases treated with the local use of sulfanilamide, there were four infections, an incidence of 8.1 per cent.

Mueller and Thompson,[20] of Roosevelt Hospital, recommend the local use of sulfanilamide when any form of peritonitis is encountered at operation. O'Donoghue and Jacobs[14] recommend the use of sulfanilamide in cases showing bacterial contamination. Griswold and Antoncic[8] report the use of sulfanilamide in the peritoneal cavity, and in the wound, in 12 cases, with one death. They also made blood studies showing that the concentration of sulfanilamide in blood rapidly reached a peak of about six milligrams per 100 cc. of blood, with a gradual disappearance in 24 to 48 hours. We have used 8 –12 grams of sterile sulfanilamide powder. The drug is sprinkled at the site of perforation and also the entire area exposed by the incision. In the process of wound closure one or two grams are placed in the abdominal wall.

We believe that several factors besides chemotherapy merit consideration for the improvement noted in our report, *i.e.*, Wangensteen suction and parenteral administration of fluids. Wangensteen suction affords physiologic rest to the stomach. It prevents vomiting with lessened strain on the wound. It prevents gastric distention, with lessening of consequent tension on serosal sutures. We wish to stress the importance of the preoperative use of Wangensteen suction.

As soon as the diagnosis is made at the hospital, Wangensteen suction is begun. This helps to prevent the spilling of gastric contents into the peritoneal cavity because perforation frequently occurs when the stomach is filled. This spilling causes peritonitis. There is usually a period of several hours before operation is performed. This is valuable time lost. The time is consumed in blood studies, roentgenologic studies, preparation of the patient, setting-up of the operating room, and summoning the Attending Surgeon. During this time, continuous Wangensteen suction prevents further spilling into the peritoneal cavity. Likewise, lessened spilling will occur as a result of forceful respiration during the induction stage of general anesthesia.

By means of parenteral therapy of intravenous administration of saline or glucose solution, plasma or whole blood, as indicated, fluid balance and nutrition is better maintained. The incidence and severity of pulmonary complications is materially lessened by the intravenous administration of an appropriate sulfonamide during that period when a sick patient cannot take sufficient by mouth.

SUMMARY.—A total of 254 cases were studied. The clinical diagnosis of perforated peptic ulcer was correct in more than 95 per cent of cases. There were 246 operations performed, with 48 deaths, an operative mortality of 19.5 per cent. This is compared with a series of 49 recent cases in which sulfanilamide was implanted in the peritoneal cavity and in the wound, with two deaths, an operative mortality of four per cent. In a total of 246 operated cases there were 63 instances of wound infection, an

incidence of 25.6 per cent. In the 49 cases treated with intraperitoneal implantation of sulfanilamide there were four wound infections, an incidence of eight per cent. The importance of the preoperative use of Wangensteen suction is emphasized.

CONCLUSIONS

The implantation of powdered sulfanilamide in the peritoneal cavity and in the wound is indicated in the surgical treatment of perforated peptic ulcer. It is an effective agent in reducing mortality and lessening the occurrence of postoperative infection of wounds.

REFERENCES

1 Berson, H. L.: Acute Perforated Peptic Ulcer: An 18-year Survey. Am. J. Surg., **56**, 385–394, May, 1942.

2 Davison, T. C., and Rudder, F. F.: Factors Influencing the Mortality of Perforated Peptic Ulcer. South. Surgeon, **9**, 75–85, February, 1940.

3 DeBakey, M., and Odom, C. B.: Significant Factors in the Prognosis and Mortality of Perforated Peptic Ulcer. South. Surgeon, **9**, 425–436, June, 1940.

4 Donald, D. C., and Barkett, S. J.: Acute Perforated Peptic Ulcer Syndrome with Surgical Management. Am. J. Surg., **56**, 406–413, May, 1942.

5 Eliason, E. L., and Thigpen, G. M.: The Effect of Perforation on Peptic Ulcer Results. Amer. J. Surg., **41**, 419–426, September, 1938.

6 Fallis, L. S.: Perforated Peptic Ulcer: An Analysis of 100 Cases. Amer. J. Surg., **41**, 427–437, September, 1938.

7 Graham, R. R.: The Treatment of Perforated Duodenal Ulcers. Surg. Gynec., and Obst., **64**, 235–238, February, 1927.

8 Griswold, R. A., and Antoncic, R. F.: Perforated Peptic Ulcers. ANNALS OF SURGERY, **113**, 791–798, May, 1941.

9 McCreery, J. A.: Perforated Gastric and Duodenal Ulcer. ANNALS OF SURGERY, **107**, 350–358, March, 1938.

10 MacGuire, C. J.: Personal communication.

11 Martz, H., and Foote, M. N.: Analysis of 50 Cases of Perforated Peptic Ulcer. Amer. J. Surg., **48**, 634–640, June, 1940.

12 Parker, E. F.: The Late Results in Acute Perforated Peptic Ulcer Treated by Simple Suture. Surgery, **10**, 49–63, July, 1941.

13 Marshall, S. F., and Keleher, P. G.: Management of Acute Perforation of Peptic Ulcer. Surg. Clin. N. A., **20**, 757–766, June, 1940.

14 O'Donoghue, J. B., and Jacobs, M. B.: Acute Perforation of Gastric and Duodenal Ulcer: A Study of 200 Consecutive Operated Cases. Ill. Med. Jour., **81**, 62–69, January, 1942.

15 Read, J. G.: Review of 100 Cases of Ruptured Peptic Ulcer. South. Surg., **7**, 436–442, October, 1938.

16 Ross, A., and Letourneau, C.: Perforated Peptic Ulcer: Analysis of a Series of 228 Consecutive Cases. Can. M. A. J., **41**, 473–479, November, 1939.

17 Ross, J. C.: Perforated Peptic Ulcer; A Review of 175 Personal Cases. Brit. M. J., **2**, 665–667, November, 1940.

18 Sangster, A. H.: Perforated Peptic Ulcer: An Analysis of 100 Consecutive Cases. Lancet, **2**, 1311–1313, December 23, 1939.

19 Thompson, H. L.: Acute Perforation of Peptic Ulcer: Immediate and Late Results in 500 Cases. J. A. M. A., **113**, 2015–2019, December 2, 1939.

20 Mueller, R. S., and Thompson, J. E.: The Local Use of Sulfanilamide in the Treatment of Peritoneal Infection J. A. M. A., **118**, 189–193, January 17, 1942.

DISCUSSION.—Constantine J. MacGuire, M.D., (New York): This review by Dr. Timoney on perforated peptic ulcers is very well justified. In his bibliography he quotes 17 previous reviews in this country and England, and his series of 254 cases is the largest in that group with the exception of that by H. L. Thompson.[19]

St. Vincent's Hospital has one of the most active ambulance services in the City, which makes the findings in this paper all the more significant. It is rather striking that through all the reports the mortality percentages correspond rather closely; the largest being between 15 and 30 per cent, with the exception of Roscoe Graham's[7] report on 51 cases with only a two per cent mortality. This is very difficult to understand, and may be explained by the relatively small number of cases. In all reports there is usually a wide group of operators because these cases come in at night as emergencies and are subjected to a rotating list of surgeons, but the main factor seems to be the interval between onset and operation rather than the skill of the individual operator. It is interesting to note that although the lowest morality was in those operated upon under six hours and next those operated under 12 hours, that those operated upon over 24 hours had a lower mortality than those between 12 and 24 hours.

There has always been a certain amount of dispute as to the site of these ulcers. They are usually in the region of the pylorus, and it is often difficult to determine whether they are prepyloric or postpyloric. Personally, I believe that a rough yard-stick is as follows: Perforation is twice as frequent prepyloric as duodenal, while massive hemorrhage is twice as often duodenal as prepyloric. One hundred seventy-four of these cases had roentgenograms taken before operation, and I think that the fact only 91 were positive for air under the diaphragm would be an indication that roentgenograms can be dispensed with if it is going to be the cause of delay.

Some clinics have advised immediate resection in these cases. I think we all feel that resection should be reserved for those callous ulcers with large perforations, with cheesy walls, which are hard to close. Many of these perforations are very small and easily closed, and the patient recovers without subsequent ulcer symptoms. The percentage can only be established by careful and complete follow-up records. I know that Dr. Timoney attempted this, and felt that the percentage of return visits was not large enough to justify conclusions. This, once again, proves what we have all learned so painfully, that for statistical purposes follow-up systems are worthless unless the percentage of returns is over 90 per cent.

Forty-nine cases were treated with sulfanilamide in the peritoneum. Conclusions based on this number of cases must be guarded, but the drop in the mortality percentage is impressive. I feel that it is imperative, where sulfanilamide is used, that drainage is employed, as in ctrtain cases the use of the sulfa drugs excites marked peritoneal exudate, enough to alarm the nurses in attendance. If no drainage is employed this exudate has been known to lead to great distension and paralytic ileus. I am now referring not only to perforated ulcers but to any abdominal case where this drug is employed.

These statistical analyses of a rather common and dramatic surgical emergency are very useful, and I would like to see Dr. Timoney give a subsequent report at the end of another five years.

ATRESIA OF THE DUODENUM

A CASE SUCCESSFULLY TREATED BY DUODENODUODENOSTOMY

CHARLES S. WARD, JR. M.D., AND FREDERICK W. COOPER, JR. M.D.

ATLANTA, GA.

FROM THE DEPARTMENT OF SURGERY, EMORY UNIVERSITY, ATLANTA, GA.

COMPLETE CONGENITAL ATRESIA of a segment of the small intestine is a fatal condition unless the patient is operated upon early. Since the first case of congenital atresia of the duodenum successfully treated by operation was reported by Ernst,[1] in 1916, many reports have appeared in the literature. However, only 14 patients with a complete atresia of the duodenum have survived. For this reason, the following case is added to the list of successful anastomoses.

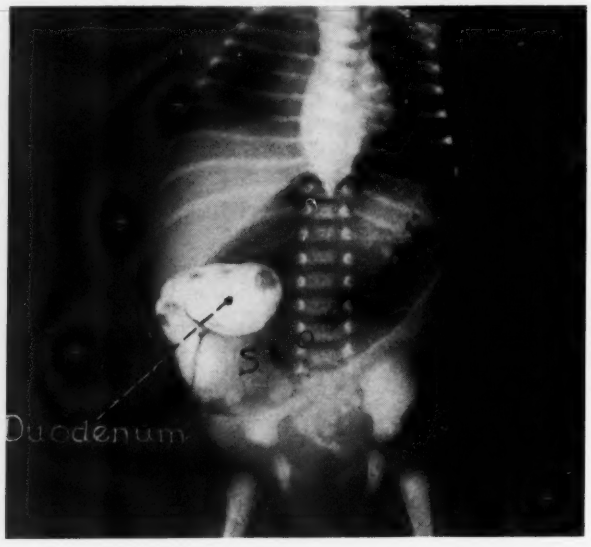

FIG. 1.—Barium study of stomach showing markedly dilated stomach and duodenum.

Case Report.—The patient was a 3.08-kilogram newborn female who, upon examination at birth, revealed no abnormalities. Breast feedings and dextrose water by mouth were begun six hours after birth. Meconium was normal in appearance. When 36 hours old the patient began to vomit dark brown viscid material, and upper abdominal distension, without visible peristalsis, appeared. Her appetite continued unimpaired. A plain film of the abdomen revealed a greatly dilated stomach but no gas in the small intestine. Barium administered by mouth was found to fill the stomach and proximal duodenum, but none passed beyond the obstructed point (Fig. 1). A barium enema showed the position of the colon to be normal. *Clinical Diagnosis:* Congenital obstruction of the duodenum. To combat the dehydration, a constant intravenous drip of dextrose and plasma was begun immediately. The contents of the stomach were aspirated through a small rubber catheter.

Operation.—At the age of five days, under drop-ether anesthesia, the abdomen was entered through a right rectus, muscle-splitting incision. The stomach and proximal duodenum were markedly dilated. There was a complete atresia in the second portion of the duodenum with the duodenum represented by a fibrous cord for a distance of two centimeters (Fig. 2a). The impression was that the atresia was distal to the papilla of Vater. Because of the size of the structure, the common bile duct was not identified. The remaining intestine was collapsed and in normal position. No bile was seen when the distal intestine was opened. An anastomosis was performed between the end of the dilated second portion of the duodenum and the side of the third portion (Fig. 2b).

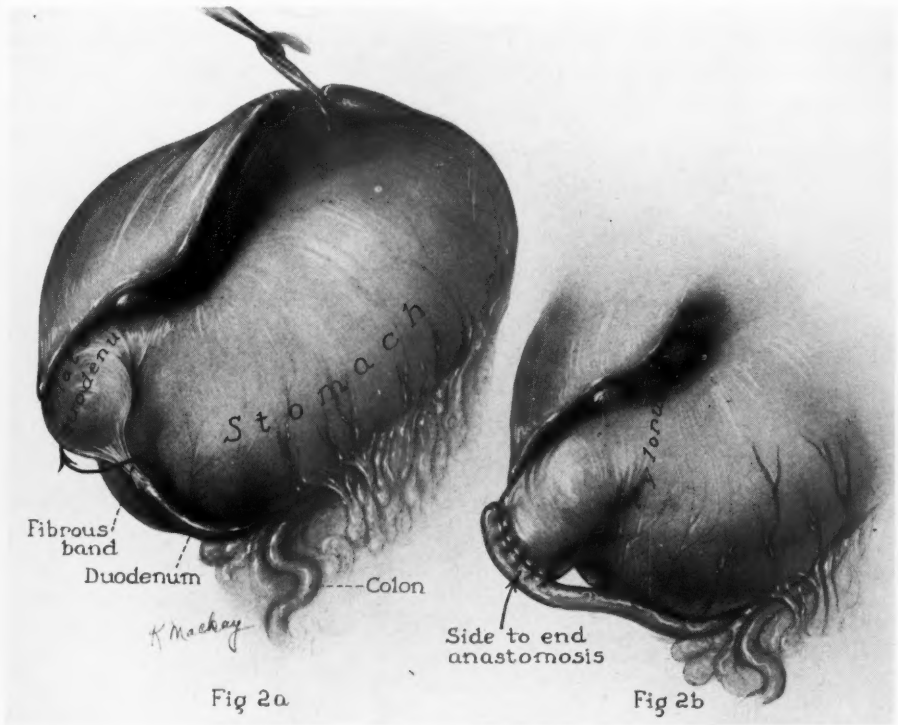

FIG. 2.—Drawing illustrating (a) the obstructed duodenum with the intestine represented by a fibrous cord; and (b) the operation, a side-to-end anastomosis, which was performed.

The anastomosis consisted of two layers of sutures: (1) An external layer of interrupted No. a silk serosal Lembert sutures; and (2) a continuous internal No. 00000 chromic catgut suture including all layers. The peritoneum was closed with a continuous No. 00 chromic catgut suture and the remainder of the wound closed in layers with interrupted black silk.

Postoperative Course.—Plasma and fluids were continued intravenously and the stomach was aspirated at frequent intervals. On the third postoperative day dextrose water was given by mouth and the following day a milk formula. There was occasional vomiting during the next four days. The plasma protein level was 4.3 Gm. per cent. After the administration of plasma the vomiting ceased. A barium study of the stomach demonstrated a functioning anastomosis (Fig. 3). The recovery thereafter was uneventful.

Follow-Up.—At the age of three months barium studies showed no duodenal obstruction nor delayed emptying of the stomach. Weight gain and development were normal.

DISCUSSION.—The fourteen successfully treated cases of proven complete obstruction of the duodenum are detailed in Table I, together with the site of obstruction and the type of operation performed. It is generally agreed that if the occlusion of the duodenum is above the papilla of Vater a gastro-enterostomy is the least formidable procedure. However, if the atresia is below the papilla of Vater, a duodeno-enterostomy should be performed, for it is readily apparent that here a gastro-enterostomy would necessitate a reflux of bile and pancreatic secretions back through the pylorus into the stomach. If the pylorus does not readily permit this reflux, gangrene and perforation of the blind pouch may occur. The entire small bowel should be inspected at the time of operation because of the frequency of multiple anomalies of the intestine.

FIG. 3.—Gastro-intestinal series showing functioning anastomosis.

Probably in no branch of surgery is the pre- and post-operative management of the patient so important as in these cases. A recent article, by Maris, McGuinness, Lee, Rhoads, and Lee,[14] advocates the use of a metal-tipped gastroduodenal tube in cases of duodenal obstruction. Its greatest usage should be at the time of exploration in eliminating the possibility of terminating an operation before the lumen is patent. Frequently the distal bowel does not distend following the release of an obstruction enough to eliminate the possibility of a second obstructing point. If the metal-tipped tube is passed into the first portion of the jejunum at the time of operation, considerable postoperative difficulty may be avoided. The degree of the patient's hydration should be carefully watched, and free use of plasma and blood should be made as indicated by the plasma protein and hematocrit determinations.

The diagnosis should be established as early as possible and operative intervention for the reestablishment of the continuity of the bowel delayed only for purposes of obtaining a better operative risk through hydration and transfusion of the patient.

Frequent aspiration of the contents of the stomach during the immediate

postoperative period is a necessity because of the tendency of infants to swallow large quantities of air.

No report of a similar case in which a duodenoduodenostomy was successfully performed appears in the literature.

TABLE I

SYNOPSIS OF 15 SUCCESSFULLY TREATED CASES OF ATRESIA OF THE DUODENUM

	Author	Age at Oper.	Sex	Site of Atresia	Operation Performed
1	Ernst, N. P.[1] (1916)	11 days	M.	Below papilla of Vater	Duodenojejunostomy
2	Cutler, G. D.[2] (1924)	4 days	..	.....	Post.gastro-enterostomy
3	Richter, H. M.[3] (1924)	4 days	..	.....	Post.gastro-enterostomy
4	Bolling, R. W.[4] (1926)	9 days	F.	.....	Duodenojejunostomy, anterior to colon
5	Porter and Carter[5] (1927)				Not stated
6	Weeks, A. and Delprat, G. B.[6] (1927)	6 days	..	3rd portion duodenum	Gastro-enterostomy
7	Sweet, G. B. and Robertson, C.[7] (1927)	10 days	F.	3rd portion duodenum	Anterior gastro-enterostomy. Duodenojejunostomy (21st day)
8	Donovan, E. J.[8] (1936)	9 days	..	At point where superior mesentric crosses duodenum	Duodenojejunostomy, ant. to colon
9	Morton, J. J. and Jones, T. B.[9] (1936)	4 days	..	3rd portion duodenum	Post. gastro-enterostomy
10	Morton, J. J. and Jones, T. B.[10] (1936)	12 days	F.	2nd portion duodenum	2mm.-thick diaphragm removed by cautery
11	Miller, E. M.[11] (1939)	8 days	..	At point crossed by superior mesenteric vessels	Duodenojejunostomy (transcolic)
12	Stetten, DeWitt[12] (1940)	3 days	M.	Duodenojejunal junction	Duodenojejunostomy
13	Fegetter, S.[13] (1940)	11 days	F.	2nd and 3rd portion of duodenum	Post. gastro-enterostomy
14	Ladd, W. E. and Gross, E. G.[14] 1932[5]	.....	..	.....	Gastrojejunostomy
15	Present report	5 days	F.	2nd portion duodenum below papilla of Vater	Duodenoduodenostomy

SUMMARY

A case of complete congenital atresia of the duodenum successfully treated by duodenoduodenostomy is presented.

REFERENCES

[1] Ernst, N. P.: A Case of Congenital Atresia of the Duodenum Treated by Operation. Brit. Med. Jour., **1**, 644, 1916.

[2] Cutler, G. D.: Cited by Clara Loitman, Congenital Occlusion of the Intestine. Boston Med. and Surg. Jour., **197**, 21, July, 1927.

[3] Richter, H. M.: Abt's. Pediatrics, W. B. Saunders, Philadelphia, **3**, 512, 1924.

[4] Bolling, R. W.: Complete Congenital Obstruction of the Duodenum, Duodenojejunostomy at Nine Days. ANNALS OF SURGERY, **83**, 543, 1926.

[5] Porter and Carter: Cited by Clara Loitman, Congenital Occlusion of the Intestine. Boston Med. and Surg. Jour., **197**, 21, July, 1927.

[6] Weeks, A., and Delprat, C. B.: Congenital Intestinal Obstruction: Atresia of the Jejunum. Surg. Clin. N. Amer., October, 1927.

[7] Sweet, G. B., and Robertson, C.: A Case of Congenital Atresia of the Jejunum with Recovery. Arch. Dis. Child. New Zealand, **2**, 186, 1927.

[8] Donovan, E. J.: Congenital Atresia of the Duodenum in the Newborn. ANNALS OF SURGERY, **103**, 455, 1936.

[9] Morton, J. J., and Jones, T. B.: Obstruction About the Mesentery in Infants. ANNALS OF SURGERY, **104**, 864, 1936.

[10] Miller, E. M.: Bowel Obstruction in the Newborn. ANNALS OF SURGERY, **110**, 587, 1939.

[11] Stetten, Dewitt: Duodenojejunostomy for Congenital, Intrinsic: Total Atresia at the Duodenojejunal Junction. ANNALS OF SURGERY, **111**, 583–596, April, 1940.

[12] Fegetter, S.: Congenital Duodenal Atresia. Lancet, **2**, 188–189, August 17, 1940.

[13] Ladd, W. E., and Gross, E. G.: Abdominal Surgery of Infancy and Childhood. Philadelphia: W. B. Saunders Co., 1941.

[14] Maris, E. P., McGuinness, A. C., Lee, H. F., Rhoads, J. E., and Lee, W. E.: The Pre- and Postoperative Use of a Metal-Tipped Gastroduodenal Tube as an Aid in the Surgical Treatment of Duodenal Obstruction in the Newborn. ANNALS OF SURGERY, **117**, 348–354, March, 1943.

CONGENITAL ATRESIA OF THE COMMON BILE DUCT

CASE REPORT

ABRAHAM STRAUSS, M.D., CAPT. JOSEPH GROSS, M.C., U.S.A.,
AND
LT. SEYMOUR KYMAN, M.C., U.S.A.
CLEVELAND, OHIO

CREDIT for the surgical treatment of congenital atresia and stenosis of the bile ducts is given by Ladd to John Thomson[6] and J. B. Holmes.[2] "In 1927, the operation was first performed successfully (by Ladd[3]) for the relief of congenital atresia of the bile ducts." Ladd and Gross[4] have covered the subject thoroughly in their book "Abdominal Surgery of Infancy and Childhood." They report on 45 cases proved at operation or autopsy. Because of the type of anomaly, Ladd was able to relieve only nine by operation. The two operable types are those that have an hepatic duct but no cystic or common duct and those that have normal gallbladders, cystic and hepatic ducts but a common duct that ends blind. The case reported herewith belongs to the second group. Ladd reported six of this type with two deaths. The ages of his cases, when referred to the hospital, varied from one week to 11 months, with an average age of three months. Although Ladd noted an abnormal bleeding tendency as a symptom in this condition, he stated his cases were free from this. Smith and Ball[5] reported a case that died following continuous hemorrhage from the umbilicus. This was a prominent complication in the case herewith reported.

Case Report.—S. G., white, female, was born October 22, 1941, one month prematurely. Birth was normal. Weight, 2600 Gm. Because the infant did not take her food properly from birth, she was given 60 cc. of Ringer's solution every other day by infusions. At the same time it was noted that the baby was becoming jaundiced, which became more marked at the end of one week. On October 29, the baby evacuated a very bloody green stool. One ampule of vitamin K was administered. The following day 30 cc. of blood was given intravenously and 20 cc. into the buttock, followed by an infusion of 110 cc. of Ringer's solution. Again, the baby passed considerable blood in the stool, and blood dripped almost constantly from the rectum. On October 31 her temperature rose to 102° F. Fifty cubic centimeters of blood was administered intravenously, and 120 cc. of Ringer's solution by infusion, in two doses. The stool was pale yellow. During this time she was given kaopectate, one-half dram every three hours; and sulfathiazole, one-half grain every six hours. Infusions and transfusions were then administered as follows:

Date	Ringer's Sol.	Blood	Other Medication
Nov. 1	70 cc.	50 cc. I. V.	Sulfathiazole and kaopectate.
Nov. 2	80 cc.	55 cc. into bone marrow	
Nov. 3	25 cc.	25 cc. I. V.	Temp. 101.6° F.
Nov. 4	....	55 cc. into bone marrow	
Nov. 5	60 cc.	60 cc. into bone marrow	
Nov. 6	70 cc.		
Nov. 7	....	50 cc. into bone marrow	
Nov. 24	40 cc.		

From November fifth on, jaundice increased and stools were acholic. Weight remained 2500–2600 Gm. Bilron was started on November 6, 1941. Operative intervention was urged, hoping that the anomaly of the bile ducts could be remedied. The baby continued to have acholic stools, but did not bleed.

Operation.—November 26, 1941: Choledochoduodenostomy. Under open ether anesthesia, the abdomen was opened through an upper right rectus incision, splitting the rectus muscle. The liver itself was found to be considerably enlarged, extending approximately two fingers' breadth below the costal margin. The gallbladder appeared normal and tense. The common and cystic ducts were dilated. The common duct ended in a blind

FIG. 1.—Roentgenogram showing catheter in common duct and duodenum.

point as it passed behind the duodenum. The condition representing a congenital atresia of the bile duct at its entrance to the duodenum. It was decided to perform a choledochoduodenostomy. A series of Deknatel "D" sutures were placed from the duodenum to a point in the common duct just above its tapering point, where a transverse incision was made in the common duct. This exposed its lumen. A No. 10 F. catheter, about two centimeters long, was then inserted into the common duct. Bile flowed from the open end of the tube. The sutures placed posteriorly were tied. A corresponding incision

was then made into the duodenum, and the free end of the catheter was inserted into the intestine (Fig. 1). Sutures were then placed in the anterior wall of the common duct and into the duodenum below the incision, and tied. This brought the duodenum and common duct together over the tube. This row of sutures was reinforced at each angle, and anteriorly, with similar interrupted Deknatel "D" sutures, thus completing a simple anastomosis between the common duct and duodenum. The abdominal wound was closed in layers with chromic No. 0, after first placing a series of through-and-through Deknatel No. 2 sutures.

FIG. 2.—The patient at age of 10 months.

On December 3, one week postoperative, the catheter that had been fitted into the common duct and duodenum was passed in the stool, which was still acholic. On December 6 the stool was light brown, but did not show positive test for hydrobilirubin until December 13. The jaundice of the skin and scleras was becoming paler. Convalescence was definitely handicapped by a severe bronchopneumonia and coryza that started on December 6. The infant was in a heated crib at all times. Oxygen and sulfathiozole were given until December 14.

The wound healed with only slight amount of serum and some separation of the skin edges, so that it finally healed superficially by granulation. The patient was discharged on December 21, on the 25th postoperative day, with very little jaundice and normal stools. At the end of one year she weighed 23 pounds.

Regarding the differential diagnosis and operability: Congenital atresia of the bile ducts must be differentiated from five other conditions presenting jaundice in the newborn:

1. In icterus neonatorum the jaundice usually disappears by the end of the second week. The liver is not enlarged and the stools contain bile pigment.

2. Erythroblastosis foetalis is usually fatal in the first few days or weeks of life. It is marked by jaundice, a large liver, and large spleen, and increased erythroblasts. It may be suspected from the golden-colored vernix caseosa and hypertrophied placenta.

3. Jaundice of hemolytic sepsis is differentiated by fever, leukocytosis, progressive anemia, toxicity, and no acholic stools.

4. Congenital syphilis may be identified by blood test and the roentgenologic appearance of the bones.

CLINICAL LABORATORY REPORTS

	11/8	11/11	11/25	12/2	12/8	12/10
W.B.C.	22,400	20,560	16,000	16,200	13,100	9500
R.B.C.	5.25	5.5	4.92	4.33		
Hb.	103%	107%	97.4%	80%	84.4%	78%

SPECIAL LABORATORY REPORTS

Specimen	Date	Report
Stool	10/30	Occult blood—positive
Blood	10/30	Hb—97.4% R.B.C.—5.18 W.B.C.—9850
Stool-culture	11/1	Culture-abundant growth *B coli*
Urine	11/5	Bile—positive. Alb.—heavy tr. Sugar—neg. Reaction—neutral Microscopic—large no. bacteria, few pus and epith. cells, mod. amt. amorphous urates. Occult blood—neg.
Stool	11/5	Clay-colored, soft, unformed. Occult blood—very slightly positive. Hydrobilirubin—neg.
Blood	11/25	Bleeding time—1½ min. Clotting time 4 min. Hb—97.4%, R.B.C.—4.88 W.B.C.—10,900 Polys—28%. Lymphs—48%. Mons—6%. Eosin—18%; R.B.C. show slight variation in size. Platelets appear normal.
Stool	12/1	Occult Blood—positive.
Stool	12/2	Bilirubin—neg.
Stool	12/2	Light colored, yellowish, soft, unformed. Presence of bile—negative.
Stool	12/1	Light colored, yellowish, soft, formed. Bilirubin, negative.
Stool	12/2	Hydrobilirubin, negative. Occult blood, pos.
Stool	12/3	Hydrobilirubin, negative.
Blood	12/11	Polys—31%, lymphs—64%, mono—3%, eosin—2%. Nucleated red cells—1 R.B.C. show variation in shape. Few R.B.C. show basophilic stippling. Lymphs appear atypical. Platelets appear normal.
Stool	12/9	Yellow, soft, formed, unaltered bilirubin.
Stool	12/10	Yellow, soft, unformed, unaltered bilirubin.
Stool	12/12	Yellow, soft, formed. Very slightly positive for unaltered bilirubin (biliverdin).

5. Obstructive jaundice from inspissated bile or mucus may give a picture indistinguishable from atresia, and may require surgery for relief. There may or may not be normal stools in the beginning as this depends on when the duct becomes occluded.

Even in cases of atresia, jaundice may not be evident until a few weeks after birth, as is reported in a case by Feldman and Lawson.[8] This infant died, age 12 weeks, weighing eight pounds. Jaundice was first noticed three weeks after birth. Postmortem examination revealed no gallbladder or cystic duct. The two small, thick hepatic ducts were present but no connection was found with the duodenum.

Watkins and Wright,[7] in reporting their binovular twin that developed jaundice six or seven days after birth, with normal stools the first few days, later becoming pale; stated: "The absence of jaundice at birth and the presence of normal meconium during the first few days have been regarded as implying that the biliary tract in such cases is at least partially patent at birth. It should be pointed out, however, that bile pigment is not present in the biliary secretions until the fifth or sixth month of fetal life (Ylppo), and from then until birth only in small amounts. After birth, bile is produced in larger quantity, but should its flow be obstructed by impervious ducts, jaundice gradually develops. In other words, the delayed onset of the jaundice coincides with the much augmented production of bile in the first few days

after birth and does not necessarily imply there is a postnatal closure of the main biliary duct tract."

One must not be misled by the color of the stools at birth. Although they may be yellow and appear normal, they will have no bile in them. Proved cases have shown that they may not become clay-colored until three to 14 days after birth.

We wish to emphasize these points because the physician may feel loathe to urge operation on certain cases of atresia that may be operable if he believes that jaundice from birth is a *sine qua non* of atresia. Thus, infants have been allowed to die, only to find postmortem that they had an operable condition. Ladd writes that, as a rule, if one delays in making the diagnosis of atresia for four to six weeks the chance of error is not great. Further delay serves no good purpose but does lower the resistance of the child so that operation may then be fatal.

Operation should be urged in atresia in spite of the fact that only 17 to 20 per cent will be operable. Ladd reported nine operable cases out of 45, with three operative deaths, and one who died four months later. Donovan had one recovery.

The case reported herewith is the seventh recorded successful operation for atresia of the bile ducts.

REFERENCES

1 Donovan, E. J.: Congenital Atresia of the Bile Ducts. ANNALS OF SURGERY, **106**, 737, 1937.

2 Holmes, J. B.: Congenital Atresia of the Bile Ducts. Am. Jour. Dis. Child., **11**, 405, 1916.

3 Ladd, W. E.: Congenital Atresia of the Bile Duct and Stenosis of the Bile Ducts. J. A. M. A., **91**, 1082; 1928; *idem:* Congenital Obstruction of the Bile Ducts. ANNALS OF SURGERY, **102**, 742, 1935.

4 Ladd and Gross: Abdominal Surgery of Infancy and Childhood. W. B. Saunders Co., Philadelphia, 1941.

5 Smith, T. Cook, and Ball, Robert T.: Congenital Obliteration of the Gallbladder with Atresia of the Extrahepatic Bile Ducts and Ampulla of Vater. Kentucky Med. Jour., **27**, 252, 1929.

6 Thompson, John: On Congenital Obliteration of the Bile Ducts. Edinburg Med. Jour., **37**, 523, 1892.

7 Watkins, A. G., and Wright, G. Payling: Congenital Atresia of the Bile Ducts. Lancet, **224**, 1066, 1933.

8 Feldman, W. M., and Lawson, Miriam A.: A Case of "Congenital" Occlusion of the Common Hepatic Duct. The Lancet, **207**, 113, July 19, 1924.

CYST OF THE AMPULLA OF VATER

CASE REPORT

BARNEY BROOKS, M.D., AND ALBERT WEINSTEIN, M.D.

NASHVILLE, TENN.

FROM THE DEPARTMENTS OF SURGERY AND MEDICINE, VANDERBILT UNIVERSITY, NASHVILLE, TENN.

Case Report.—Vanderbilt University Hospital No. 119392: A white male, age 30, was admitted to the hospital, February 2, 1942, because of repeated attacks of abdominal pain accompanied by nausea, vomiting and possibly jaundice. Although the patient emphasized the symptoms which had been present for the past year, he was able to give a detailed account of an illness occurring at the age of 15, characterized by severe epigastric pain and tenderness, nausea and vomiting, of a sufficient intensity to lead a physician to make a diagnosis of acute cholecystitis, perform of celiotomy and place a drainage tube in the gallbladder. Following the removal of this tube, the patient made an uninterrupted recovery and considered himself well until he was 26 years old, at which time he began to suffer from hemorrhoids, for which an operation was performed in February, 1941.

Approximately one month after this operation the patient had an attack of pain, deeply boring in character and entirely confined to the epigastrium. The pain reached its climax in four or five hours and was accompanied by nausea and vomiting. The symptoms persisted for about 24 hours, after which he considered himself well for a period of one month, when he experienced a similar episode.

These attacks have subsequently occurred approximately once each month. Neither the patient nor his family have noticed any discoloration of the skin or sclera, but the patient believes that his urine became dark in color after at least some of his attacks.

Ten months before admission the patient saw a physician, who made a diagnosis of peptic ulcer. On January 1, 1942, the patient began the use of the Muelengracht diet, to which regimen he has carefully adhered, without obtaining relief. His weight decreased from 190 to 150 pounds. The patient experienced his last attack approximately one week before being admitted to the Vanderbilt University Hospital.

On admission to the hospital the patient appeared as a fairly well nourished, intelligent, cooperative individual. Examination of the abdomen was particularly satisfactory because of the unusual relaxation of the abdominal wall, and no abnormalities of the abdomen were detected. The usual microscopic and chemical examination of the blood and urine showed no abnormality except for the elevation of the icteric index to 12 units, following one episode of pain. Repeated examination of the stools always disclosed the presence of occult blood. Cholecystographic examination showed a definite but faint shadow of the gallbladder.

Roentgenologic examination of the gastro-intestinal tract by means of the barium meal was of particular interest because of our failure to observe in the roentgenograms definite evidence of the unusual lesion subsequently disclosed at operation. The dilatation of the duodenum and proximal portion of the jejunum was quite obvious, but the curious filling defect in the duodenum, as shown by Figures 1 and 2, was not seen until after operation.

Operation.—February 12, 1942: The abdomen was opened to the right of the midline above the level of the umbilicus. It was noted that the gallbladder was completely obscured by adhesions, and the operator turned his attention first to an examination of the jejunum. Approximately the first two feet of the jejunum showed marked hypertrophy and dilatation. The walls of the intestine were thick and

leathery and the hypertrophy of the longitudinal muscle coat of the intestine was such as to produce gross striation. The hypertrophy and dilatation terminated almost abruptly into normal small bowel, without any evidence of obstruction at the point of termination.

Examination of the stomach and first portion of the duodenum showed nothing abnormal except for small stellate scarring of the anterior wall of the duodenum just distal to the pylorus. There was, however, in the scar no induration or other evidence of duodenal ulcer. About one inch from the pylorus the duodenum became

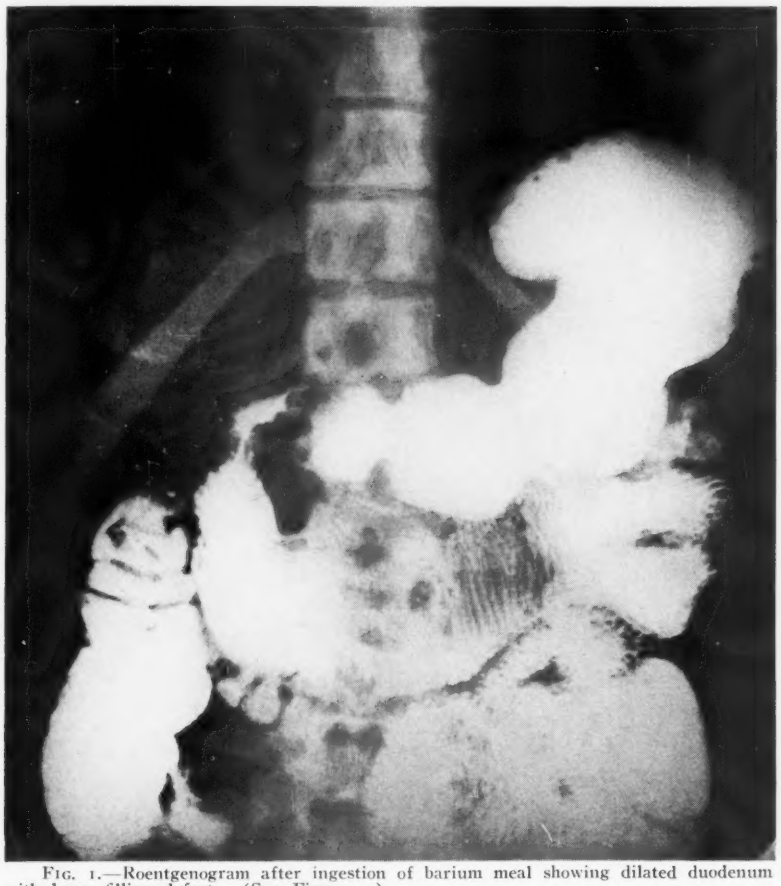

FIG. 1.—Roentgenogram after ingestion of barium meal showing dilated duodenum with large filling defect. (See Figure 2.)

greatly enlarged. The enlargement was such that the diameter of the duodenum was approximately the same as that of the stomach. On palpation, the duodenum was tense and fluctuant. When pressure was first exerted upon the tense duodenum, it could not be made to collapse, but subsequently, while handling the duodenum, the operator was aware of an abrupt partial emptying of the distended duodenum in the direction of the jejunum, which immediately became distended with fluid. Further attempts to empty the duodenum were unsuccessful. An incision was then made in the posterior peritoneum along the lateral wall of the duodenum, which, thus mobilized, was delivered into the operative wound. A longitudinal incision approximately ten centimeters in length, was then made through the anterior duodenal wall. The duodenum was found to contain a large polypoid mass which, when delivered through the incision in the duodenum, was found to be attached to the posterior wall of the descending portion

of the duodenum. The polypoid mass was estimated as measuring 8 cm. in diameter and 12 to 15 cm. in length—(note the mass was considerably reduced previous to the opening of the duodenum). The operator observed that if the tumor was stretched towards the left, it was sufficiently long to reach for some distance beyond Treitz' ligament. The entire polypoid mass was covered with what appeared to be normal duodenal mucosa. At the apex of the tumor there was a slit-like opening which, after

FIG. 2.—Tracing of roentgenogram shown in Figure 1.

its edges were separated, permitted the discharge of a large amount of golden-yellow bile. If the edges of the slit were not held apart, a considerable amount of pressure could be exerted upon the tumor without causing the discharge of bile (Fig. 3).

An incision was made through the anterior aspect of the tumor and it was found that the central portion of the tumor was occupied by a cavity lined with mucosa, which had the same appearance as the mucosa of the duodenum. On careful examination it was noted that there were two small openings into the central cavity. These openings were approximately two millimeters apart, one being slightly larger than the other. A probe passed into the larger opening followed the pedicle of the tumor

into what appeared to be quite normal common bile duct. A probe passed into the other opening apparently followed the direction of the duct of Wirsung. The cavity within the polyp communicated with the lumen of the duodenum by means of a slit-like opening at the tip of the tumor (Fig. 4).

A circular incision was made about the apertures of the common bile duct and pancreatic duct (Fig. 4), and all of the muscosa lining the central cavity except that contained within the circular incision was removed. The greater portion of the mucosa covering the polypoid mass was then removed. This resulted in what appeared to be

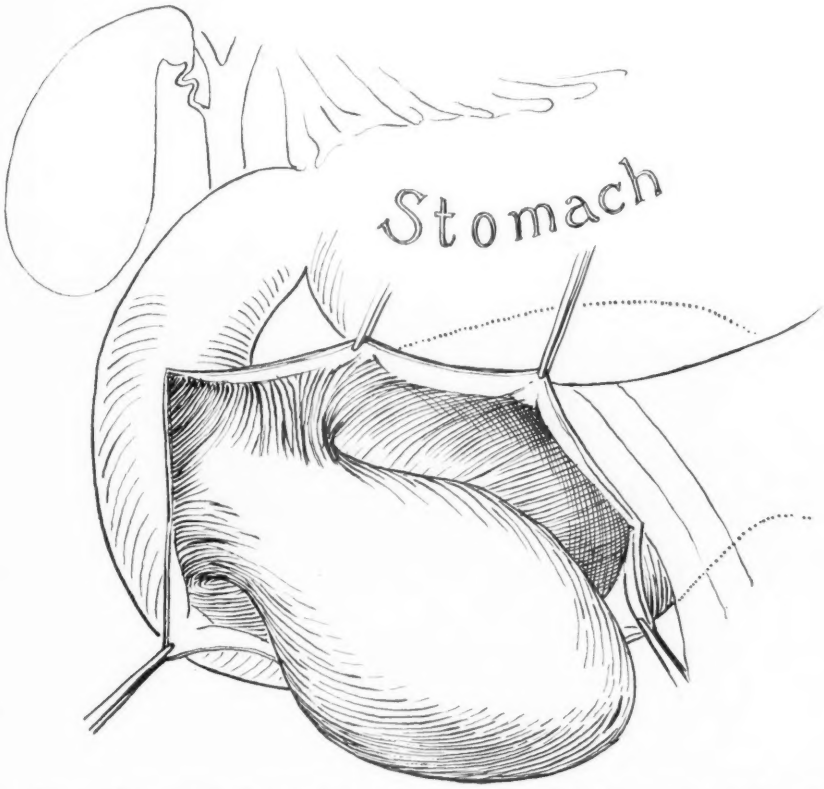

FIG. 3.—Diagrammatic illustration of the appearance of the duodenum after it was opened. The polyp was relatively longer and had a more bulbous tip than is shown in this illustration. The slit-like opening is almost as obscure in the illustration as it was in reality.

a linear incision of the mucosa of the posterior wall of the duodenum, within which there was a separate island of mucosa derived from the mucosal lining of the central cyst. The mucosa of the posterior wall of the duodenum was then closed, incorporating the island of mucosa surrounding the openings of the bile and pancreatic ducts (Fig. 5). The incision in the anterior wall of the duodenum was then closed by a double row of inverting sutures.

The gallbladder was then exposed by separation of the surrounding adhesions, and, on palpation, was found to contain a few small stones. An incision was made at the tip of the gallbladder and the stones removed. The operator hesitated to remove the gallbladder for fear that a subsequent constriction would form at the opening of the common bile duct into the duodenum. A small tube was, therefore, placed in the fundus of the gallbladder and brought out through a stab wound at the right costal margin. The abdominal incision was closed in layers.

The patient's postoperative course was uneventful. He was discharged from the hospital on the 12th postoperative day. During the year following operation the patient has enjoyed excellent health, and has gained 40 pounds. When reexamined a year after operation he appeared to be in perfect physical condition. At this time roentgenologic examination of the gastro-intestinal tract revealed slight dilatation only of the upper portion of the jejunum, with no evidence of obstruction.

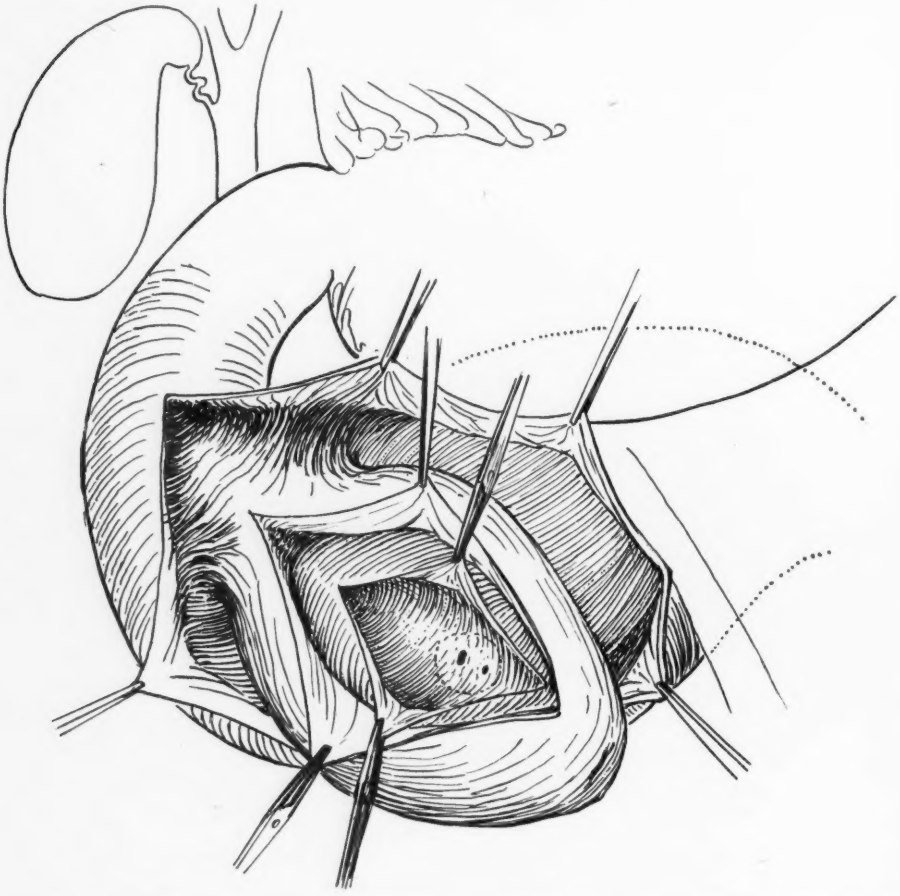

FIG. 4.—Diagrammatic illustration of the appearance of the polypoid tumor after an incision was made into the central cyst. The dotted line around the apertures of the bile and pancreatic ducts marks the site of the incision made for preserving this area of mucosa for subsequent transplantation into the posterior duodenal wall.

DISCUSSION

The term, cyst of the ampulla of Vater, is used in the title of this paper because it seemed best suited for making this report available in the current medical indices to those subsequently interested in this subject, but in reality the conditions present were not as simple as this term implies.

Whatever the cause of the initial anomaly at the normal site of the ampulla of Vater was, it seems quite certain that the outstanding anatomic characteristics of the tumor, the duodenum and proximal jejunum, as well as the

major symptoms present, were because of the intussusception of the cyst. In fact, it is difficult to understand how so large a mass could exist in the duodenum without more discomfort than the patient appeared to have. The hypertrophy of the jejunum for a distance greater than the length of the tumor is easily accounted for by the bulbous end of the tumor, which if once engaged in peristaltic waves would result in the jejunum being drawn on to the intussuscepted mass after its further progress were impossible because of the attachment of its pedicle.

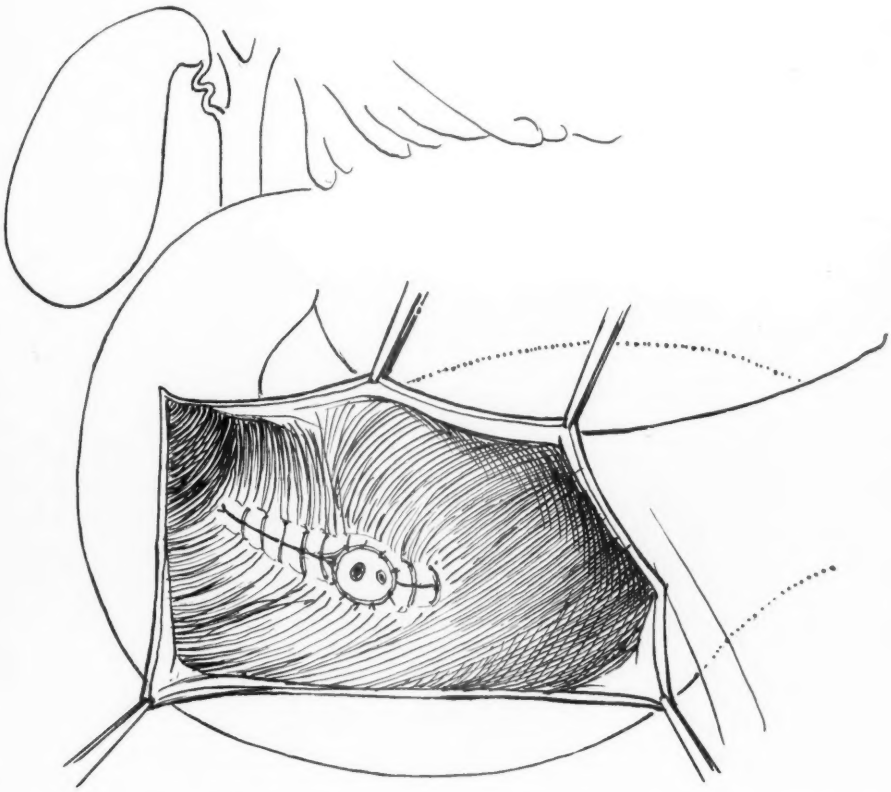

FIG. 5.—Diagrammatic illustration of the method of closure of the wound in the posterior wall of duodenum containing the transplant of mucosa from the central cyst.

The explanation of the initial anomaly is by no means as simple as the title of this report implies. Although the slit-like opening in the distal end of the polypoid tumor seemed quite analogous to the aperture of the normal ampulla of Vater, and the common bile duct and the duct of Wirsung opened into the cyst, it appeared impossible to consider the cyst as having been acquired from a dilatation of the canal within the ampulla, because the slit-like opening of the cyst into the duodenum was really larger than the aperture of the normal ampulla, and because the cyst was lined with a mucosa which, on both gross and microscopic examination, was identical with the

normal mucosa of the duodenum. Also, the openings of the bile and pancreatic ducts were at the distal aspect of the cyst.

It appears, therefore, as if the abnormality described herewith was a congenital anomaly of the duodenal wall and not an acquired dilatation of the ampulla of Vater. The authors were unable to find a record of a similar condition having been observed except perhaps the "anomalous pouch" of the duodenum reported by J. C. Boileau Grant.[1]

The nature of the symptoms experienced by the patient at the age of 15, is strongly presumptive evidence of the existence of the polypoid tumor at that time. In this connection, it is interesting to note the remarkable change in the patient's definition of being "well" before and after operation. Before operation the patient believed himself "well" between "attacks of severe pain, nausea and vomiting" only occurring during the year previous to operation. One year after operation he stated that he had, since the operation, enjoyed a feeling of comfort and well-being previously unknown to him.

REFERENCE

[1] Grant, J. C. Boileau: Anomalous Duodenal Pouch. Brit. Jour. Surg., **23**, 233, July, 1935.

HYPERESTHESIA OF THE POSTERIOR PERITONEUM (Objective Pain) IN APPENDICITIS AND OTHER VISCERAL LESIONS

RAFAEL CAPURRO, M.D.

MONTEVIDEO, URUGUAY

FROM THE SURGICAL SERVICES OF THE MILITARY HOSPITAL, THE SOCIEDAD ESPANOLA, AND THE SANOTORIO OBRERAS Y EMPLEADAS, MONTEVIDEO, URUGUAY.

IN A SERIES of cases of appendicitis, we have been brought to consider that there exists a zone of objective pain in the region of the iliacus muscle (Plate I, Fig. 3). These cases included chronic and acute appendicitis, with little or no spasticity of the abdominal wall (such as catarrhal or diffuse appendicitis, with a weak peritoneal reaction). That is to say, that the deep palpation of this area just internal *to* and *above*, the crest of the anterior iliac spine provokes a pain that is quite localized (Fig. 1). This painful reaction is completely independent of the position of the appendix. It facilitates the diagnosis and in certain cases determines it.

In October, 1941, we had the opportunity to utilize the advantages of local anesthesia in performing direct palpation of the iliacus muscle with the finger tip (Plate I, Fig. 1). In a case of catarrhal appendicitis a reaction was elicited by touching the external interior portion of iliacus muscle in the same manner as clinical palpation and elicited an earlier painful response. A logical deduction was that if there was a zone of objective sensitivity determinated by the lesion in the appendix; the anesthesia of the meso-appendix with novocain should eliminate this hyperesthesia by blocking the sympathetic pathway (Plate I, Fig. 2).

On the same day we operated upon two cases of appendicitis. One, a diffuse, acute appendicitis, with a weak peritoneal reaction; the other, an appendicitis of long standing, with recurring attacks. In both cases there was an objective painful response on palpation of the iliacus muscle region which disappeared in each of the two cases after injection of one per cent novocain into the meso-appendix.

These observations were continued until 53 cases had been checked by our own and other surgeons' observations. In all but one of these the results were positive. The exception gave evidence of objective pain on external palpation but upon operating we were unable to elicit the painful response area by direct digital palpation. It is possible that the diffuse anesthesia of the abdominal wall in this case may explain this aberrant result.

At this stage of our investigation we considered the probability that if lesions of the appendix provoked hyperesthesia in the posterior abdominal wall, then it was possible that lesions of other organs might induce hyperesthesia in other regions of the posterior abdominal wall. This line of reasoning was subsequently investigated as follows:

In salpingo-oophoritis we found the zone of hyperesthesia to be on the body of the first sacral vertebra near the sacral wing. Right or left according to the site of location of the lesion. It would be difficult with local anesthesia to operate upon a case of salpingo-oophoritis and to palpate the region directly, and thus cause the disappearance of pain by novocain injection of the mesosalpinx and mesovarium. However, in lesions of the external genitalia of the male (epididymitis) the same area of hyperesthesia was found as

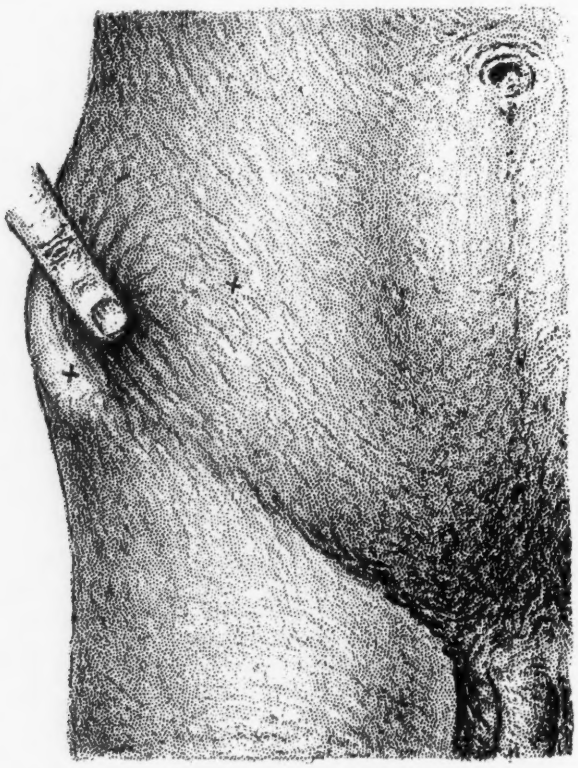

FIG. 1.—Deep palpation of the abdomen about 2 cm. medial and 2 cm. superior to the anterior iliac spine. Objective pain is diagnostic of a lesion of the appendix. × marks McBurney's point.

for salpingo-oophoritis. This reflex pain disappeared after novocain infiltration of the scrotal cord.

In looking for the areas of hyperesthesia in lesions of the stomach, duodenum, and gallbladder; they appear, from our few observations, to be on the bodies of the lumbar vertebrae at the level of the umbilicus. In kidney lesions the zone appears to be on the iliac crest at the anterior axillary line, and is lateral to the ureter.*

Returning to the study of appendicitis, we were faced with the question of the location of the seat of pain. Is it in the iliacus muscle or in the peri-

* This much of our work was presented before the "Surgical Society of 'Montevideo'" in April, 1942.

toneum which covers it, or possibly the femoral cutaneous nerve? The extent of the pain area eliminates the possibility of direct compression of the nerve as being responsible. McKenzie has described a reaction of sensitivity in the iliopsoas muscle in lesions of viscera whose innervation corresponds to the metameric 11th or 12th thoracic segments. He did not mention special localization in specific zones for specific organs.

We had the opportunity of performing three experiments that suggested that the pain area appeared to be in the peritoneum and not in the muscle: In these three cases of appendicitis, operated upon under local anesthesia, we carefully freed the peritoneum from the surface of the iliacus muscle (Plate I, Fig. 4). Digital pressure on the muscle induced no painful response, whereas compression of the peritoneum between two fingers one extra- and the other intraperitoneal, provoked the painful reaction which, in turn, was eliminated by novocain infiltration of the meso-appendix.

PHYSIOPATHOLOGY

The results we have described follow the accepted explanation of objective painful reflex responses. One must remember that the visceral peritoneum receives its innervation from the thoracolumbar sympathetic and from the craniosacral parasympathetic systems. On the other hand, the parietal peritoneum is innervated by the spinal nerves. In the case of a lesion of the appendix, the visceral afferent nerves convey impulses to the spinal cord, and connections are made with efferents of the 11th and 12th thoracic segments, which are those involved in the innervation of the parietal peritoneum covering the iliacus muscle. Injection of novocain into the meso-appendix eliminates the reflex at its source.

Clinical application of this test has been made by myself and other surgeons in 200 cases. The physical examination of patients with appendicitis, with little or no abdominal spasticity, have been made as follows:

CLINICAL APPLICATION

(1) Palpation of the anterior wall of the iliac fossa (McBurney).

(2) Visceral palpation to make direct contact with the cecum and appendix in order to determine the presence or absence of pain in this organ. Distinction is made between visceral and anterior abdominal wall pain by the well known procedure of an attempt by the patient to raise himself.

(3) Deep palpation of the iliac fossa, as described previously: It is necessary to use all four fingers at first. When the zone of hyperesthesia has been found, an index finger is sufficient for the subsequent palpation. Frequently the cecum can be displaced and, also, the edge of the psoas can be felt, and the area more sharply defined.

The facts obtained by these observations can be schematically applied:

(1) Acute catarrhal appendix, or diffuse type, with little peritoneal reaction:

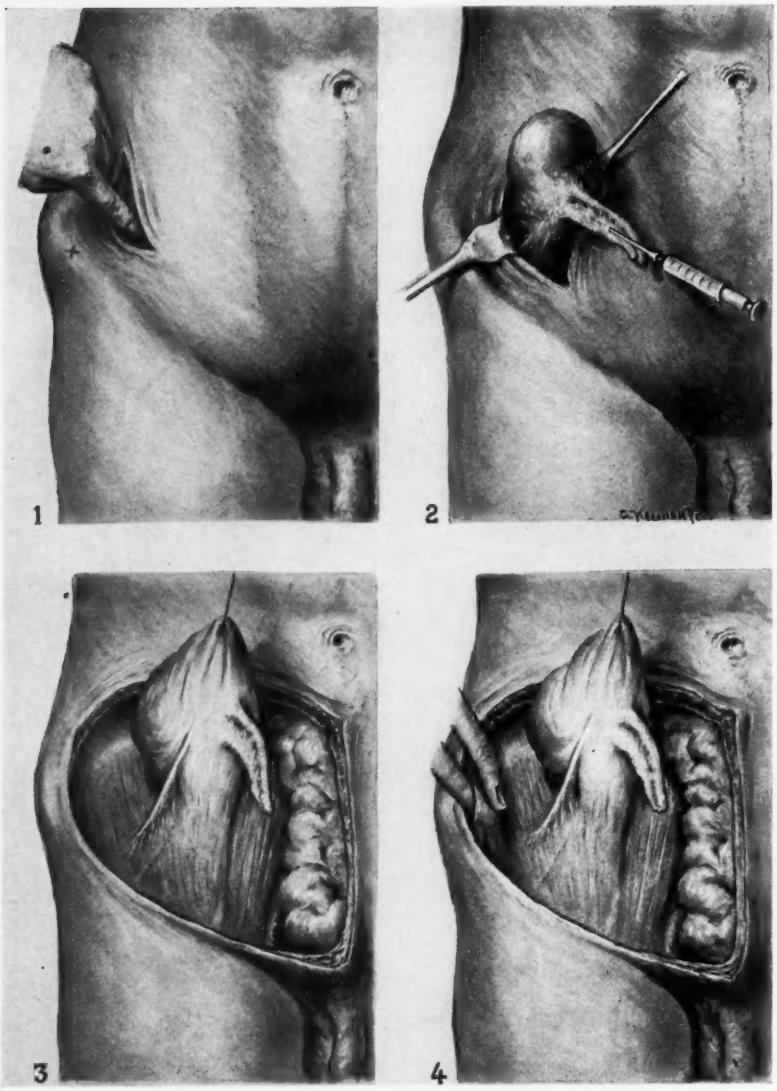

PLATE I, FIG. 1.—Direct pressure on the posterior parietal peritoneum covering the iliac fossa: If objective pain is elicited, it can be blocked by infiltration of the meso-appendix with novocain as indicated in Figure 2.

FIG. 2.—The cecum and appendix are brought out of the incision and about 3 cc. of 2% novocain is injected into the meso-appendix.

FIG. 3.—Anatomic exposure of the iliac fossa showing the area of hyperesthesia.

FIG. 4.—During operation the posterior, parietal, and abdominal peritoneum can be freed, so that pressure can be applied to the muscle directly, or to the peritoneum, between two fingers, as shown. The same pressure after novocain has been injected into the meso-appendix elicits no objective pain.

(a) Appendix in normal situation or position. McBurney point apparent, a painful appendix, and an hyperesthesia of the posterior parietal peritoneum. In these cases the test confirms the diagnosis. When McBurney's point tenderness is little apparent, the test has greater diagnostic aid.

(b) Abnormal position of the appendix, retrocolic with high cecum: Pain in the flank near the right lumbar region or in the right hypochondrium, with weak McBurney reaction, but with a clear reaction on the posterior peritoneum. In these cases the value of the test is in the differential diagnosis from renal and gallbladder lesions. A similar value appears in the case of the pelvic appendices in order to distinguish them from genital lesions.

(2) In recurring or chronic appendicitis our test should be *more* important. We have observed cases in which appendices without pain were examined radiologically. The existence of our positive test permitted the diagnosis of appendicitis, which was subsequently confirmed by operation.

One must realize that in obese and neurotic patients, and in those with hypersensitivity of the sympathetics, the deep palpation test is not possible.

Our impression is that the hyperesthesia of the posterior parietal peritoneum is more persistent than that of the anterior wall, and is, therefore, maintained in lesions of long standing. The negative result with external palpation, found only in one case out of our 200 cases of true appendicitis, might be related to a retraction of the peritoneum toward the midline found upon operating. Dr. George Pitkin, of Teaneck, N. J., reported he had successfully employed this new diagnostic procedure in a case of acute appendicitis in which there appeared no painful reaction in the anterior wall (McBurney).

Of course, experience with the test is far from complete. We do not know, for instance, its results in general infections such as typhoid, influenza, purpura, rheumatism, *etc.* Nevertheless, it may enable one to increase the percentage of positive diagnoses, and, finally, we believe that the facts we have observed have a clinical and physiopathologic significance that merits further investigation.

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METABOLIC STUDIES IN PATIENTS WITH CANCER OF THE GASTRO-INTESTINAL TRACT. XII—THE GLYCINE TOLERANCE TEST IN PATIENTS WITH GASTRIC CANCER*

IRVING ARIEL†, M.D., FLORENCE JONES, B.A., GEORGE T. PACK, M.D.,
AND
C. P. RHOADS, M.D.
NEW YORK, N. Y.

FROM THE MEMORIAL HOSPITAL, NEW YORK, N. Y.

AN EARLIER COMMUNICATION of this series[1] indicated that 59 per cent of patients with gastric cancer develop hypoproteinemia. This abnormality may be due to (a) the increased protein catabolism of these individuals; (b) their impaired ability to fabricate serum protein; or (c) simply an inadequate intake and absorption of dietary nitrogen constituents. Previous investigations[2] of nitrogen excretion as the cause of hypoproteinemia in patients bearing gastric cancer failed to demonstrate that their rate of tissue breakdown was increased. However, evidence was found which strongly suggested that these individuals no longer could synthesize serum albumin in normal amounts.[1]

Since the presence of gastric cancer conceivably could influence the motility of the alimentary tract, it was possible that that abnormality impaired the absorption of nitrogenous foodstuffs and thus contributed to the development of the hypoproteinemia in these instances. The association of gastro-intestinal disorders with impaired absorption resulting in states of deficiency has been stressed by others.[3] The present study was undertaken, therefore, to ascertain whether or not the usual end-products of protein digestion, *i.e.*, the amino-acids, were absorbed normally from the intestinal tract of patients with gastric cancer.

Methods.—Throughout the present investigation, the glycine tolerance test described by Erf and Rhoads[4] was used. Samples of oxalated blood for the determination of plasma amino-acid nitrogen[5] were obtained from the fasted patient at 0, 1, 2, 3, and 4 hours after his ingestion of 25 Gm. of glycine in 500 Ml. of water.

The urea content of the samples taken at 0, 2, and 4 hours after glycine feeding was measured by the technic of van Slyke.[6]

The urinary output of amino-acid nitrogen was measured for one day before, and for two days after, the administration of glycine. These determinations were made by the method of van Slyke, *et al.*[5]

Clinical Material.—The clinical material employed in this investigation were all adults and can be divided into four groups:

* The authors gratefully acknowledge the grant from the National Cancer Institute.
† Trainee in diagnosis and treatment, National Cancer Institute Fellow.

(A) Six patients who were used as controls. They all had neoplastic lesions of the extremities.

(B) Six patients with gastro-intestinal cancer—five with adenocarcinoma of the stomach, and one with squamous cell cancer of the terminal esophagus. In all instances the diagnosis was proven by microscopic examination of biopsied material.

(C) Three patients with non-neoplastic gastric lesions—one had multiple ulcers, the second had multiple polypi, and the third suffered from diffuse Boeck's sarcoid. The diagnosis was made in these individuals by celiotomy and microscopic examination of a biopsied material.

(D) Three patients who underwent total or subtotal gastrectomy for the removal of the cancer. One of these three patients is included in Group C.

RESULTS

A. THE ABSORPTION OF GLYCINE FROM THE GASTRO-INTESTINAL TRACT OF PATIENTS WITH NEOPLASTIC LESIONS OF THE EXTREMITIES

Of the six patient with tumors of the extremities who were studied as control subjects, in five the peak of the plasma amino-acid nitrogen curve occurred during the first hour after ingestion of the glycine (Table I)

TABLE I

COMPARISON OF THE AMINO-ACID NITROGEN AND UREA NITROGEN LEVELS IN THE PLASMA OF THE PATIENTS STUDIED AFTER THE INGESTION OF 25 GM. OF GLYCINE

	Duration of Time for Peak in Plasma Amino-Acid Nitrogen to Occur	Height of Peak Above Fasting Plasma Amino-Acid Nitrogen Level		Type of Curve	Increase in Plasma Urea Nitrogen 4 Hours After Glycine Ingestion	
	Hours	Range Mg. per 100 Ml.	Average		Range Mg. per cent	Average
Patients with neoplastic lesions of the extremities	1	1.8–4.3	2.58	Slow drop of peak	1.5–5.1	3.0
Patients with gastric cancer	2	4.1–8.8	6.61	Sharp drop of peak	1.8–5.3	3.4
Patients with noncancerous lesions of the stomach	1	3.8–5.5	4.53	Slow drop of peak	1.6–8.2	5.3
Patients subjected to gastrectomy	1	3.2–9.2	5.80	Sharp drop of peak	5.0–17.5	8.75

(Fig. I). In the exception (a vegetarian of 20 years duration), the peak of absorption occurred during the third hour. The average maximum increase of the level of amino-acid nitrogen in the plasma of these six patients was 2.58 mg. per cent nitrogen, and the range of increase was from 1.8 to 4.3 mg. per cent. These values are somewhat lower than the average value of 5.8 mg. per cent obtained for four normal individuals by Kirk.[7]

There is no apparent relationship between the levels of plasma amino-acid nitrogen and those of urea (Fig. I). The average maximum increase of urea nitrogen was 3.0 mg. per cent, and the range of increase from 1.5 to 5.1 mg. per cent.

The urinary excretion of amino-acid nitrogen was measured in two of the six control subjects both for the day before and the two days after the administration of glycine (Table II). In these individuals an increased

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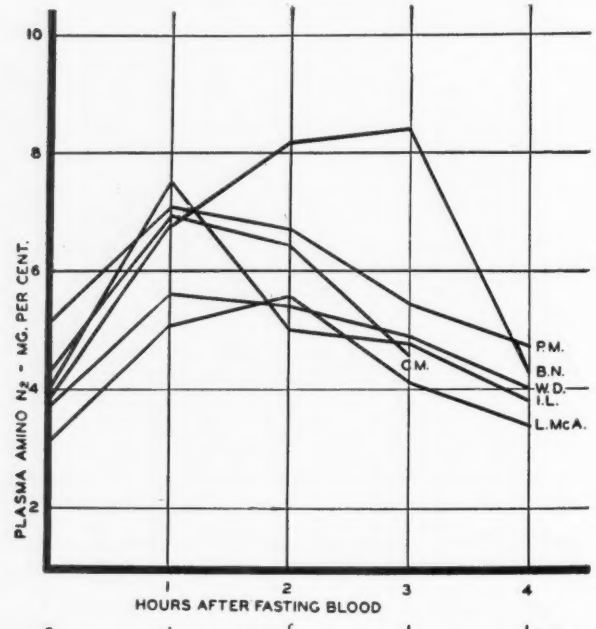

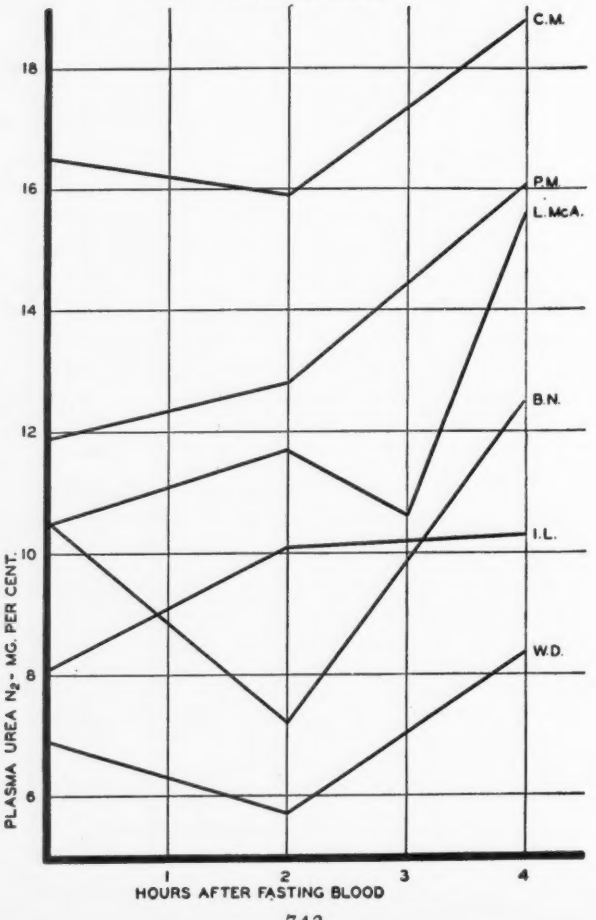

TABLE II

URINARY EXCRETION OF AMINO-ACID NITROGEN FOLLOWING THE INGESTION OF 25 GM. GLYCINE

Patient	Diagnosis	Amino-Acid Nitrogen Mg. for the 24 Hours Before Glycine Ingestion	Amino-Acid Nitrogen Mg. for the 24 Hours After Glycine Ingestion	Amino-Acid Nitrogen Mg. for the 24th to 48th Hours After Glycine Ingestion
Group A:				
L. M.	Sarcoma of thigh	172	295	75
I. L.	Sarcoma of thigh	67	142	79
Group B:				
E. Y.	Cancer of stomach	63	184	44
M. K.	Cancer of stomach	55	97	360
J. M.	Cancer of esophagus	82	172	104
I. Z.	Cancer of stomach	237	451	233
Group C:				
R. G.	Peptic ulcer	31.0	34.4	49.8
G. F.	Gastritis	57.6	66.0	

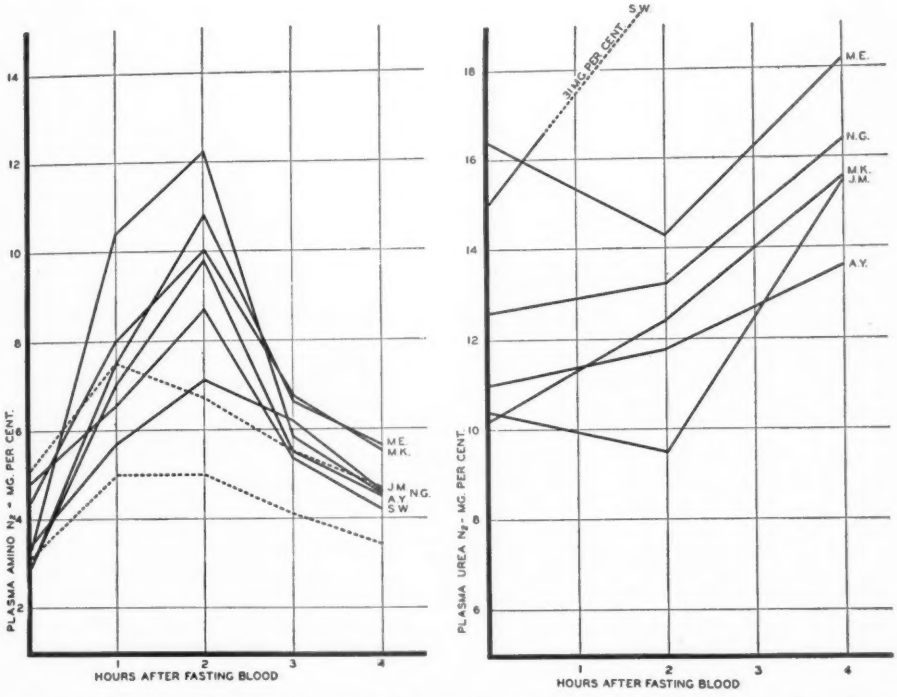

FIG. 2.—Plasma amino-acid nitrogen and urea nitrogen curves following the ingestion of 25 grams of glycine by five patients with gastric cancer and one patient with carcinoma of terminal esophagus. The area between the broken lines in the plasma amino-acid nitrogen chart represents the control levels obtained from Figure 1.

daily excretion of only 75 and 123 mg. of amino-acid nitrogen was noted after the glycine ingestion. It is interesting to note that these increased outputs represent less than one per cent of the glycine given. This observation would indicate that almost all the glycine administered was used for metabolic purposes.

B. THE ABSORPTION OF GLYCINE FROM THE GASTRO-INTESTINAL TRACT OF PATIENTS WITH GASTRO-INTESTINAL CANCER

In contrast to the findings noted in the previous group of patients, the

* FIG. 1.—Plasma amino-acid nitrogen and urea nitrogen curves following the ingestion of 25 grams of glycine by six patients with neoplastic lesions of the extremities.

peak of amino-acid nitrogen levels in the plasma of patients with gastro-intestinal cancer after the administration of glycine always occurred in the second hour. Moreover, in this group of patients the increase in the peak of the plasma amino-acid nitrogen, after the glycine ingestion of 25 Gm., was considerably higher than that observed in the previous group. The average increase was 6.61 mg. per cent, and varied from 4.1 to 8.8 mg. per cent. Thus, the average increase in the plasma of patients with gastric cancer was 256 per cent above the peak in the plasma of the control group.

The average increase of urea nitrogen in the plasma of these patients after the ingestion of glycine was found to be 5.8 mg. per cent, and the range of increase from 1.8 to 16.0 mg. per cent.

In four instance the daily urinary output of amino-acid nitrogen was measured and was found to increase for the 24 hours after administration of glycine only by from 42 to 215 mg.

Thus, it would appear that the absorption of glycine from the gastro-intestinal tract of patients bearing esophageal or gastric cancer is somewhat delayed.

C. THE ABSORPTION OF GLYCINE FROM THE GASTRO-INTESTINAL TRACT OF PATIENTS WITH BENIGN LESIONS OF THE STOMACH

To ascertain whether or not the delayed absorption of glycine by patients with gastro-intestinal cancer was due to the presence of gastric lesions and possibly to the consequent impaired gastro-intestinal motility, three patients with benign gastric disorders were studied. In these, as in the control Group A, the peak of glycine absorption occurred during the first hour. The average maximum increase of the plasma amino-acid nitrogen level was 4.53 mg., and the range of maximum increase from 3.8 to 5.5 mg. per cent. In one instance (R. G.), following a sharp drop in the plasma level of amino-acid nitrogen during the second hour, a secondary higher peak occurred. The reason for this second rise is not known, although others[7] have demonstrated a secondary third-hour peak in the curve of some normal individuals.

The maximum increase of the plasma urea nitrogen in these patients varied from 1.6 to 8.2 mg., and the average was 5.3 mg. per cent.

The daily excretion of amino-acid nitrogen was measured in the urine of two of the three individuals and was found to increase only by 9 and 18 mg.

D. THE ABSORPTION OF GLYCINE FROM THE GASTRO-INTESTINAL TRACT OF PATIENTS WHO UNDERWENT GASTRIC RESECTION

Two of the three patients in this group previously were studied before surgical removal of their stomachs. In J. M., the patient with cancer of the terminal esophagus who was presented in Group B, the peak of glycine absorption now was reached during the first instead of the second post-

absorptive hour. The height of the peak was 3.3 mg. per cent—a value somewhat lower than that noted under similar circumstances before his gastric resection (4.3 mg per cent).

In J. R., a patient who suffered from Boeck's sarcoid of the stomach and who underwent gastric resection, the peak of glycine absorption occurred in the first hour. Whereas, before surgical removal of the cancer, a lag was noted in the fall of the plasma amino-acid nitrogen level after glycine ingestion, when the stomach was resected, this "post-peak" fall was precipitous. During the test made in the preoperative period, the plasma amino-acid nitrogen increased by 3.9 mg. per cent; after the subtotal resection, the level increased by 7.1 mg. per cent.

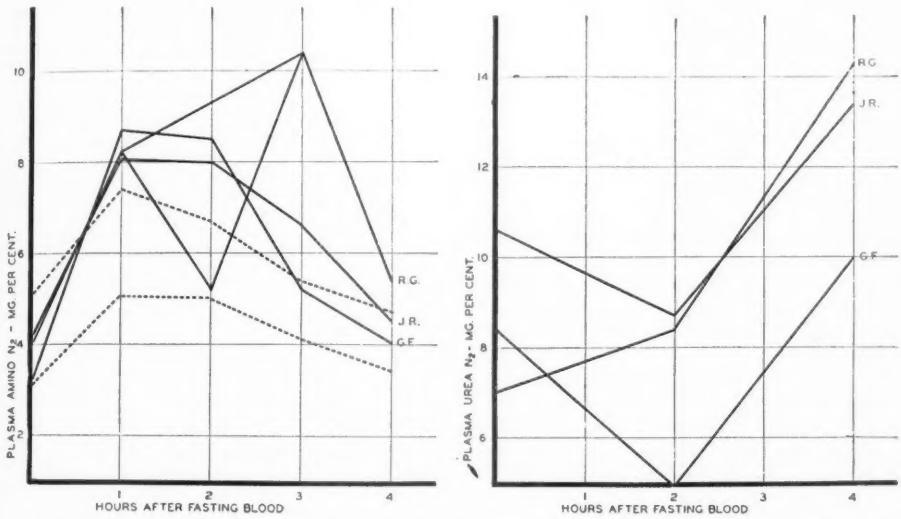

FIG. 3.—Plasma amino-acid nitrogen and urea nitrogen curves following the ingestion of 25 grams of glycine by three patients with non-neoplastic lesions of the stomach. The area between the broken lines in the plasma nitrogen chart represents the control levels obtained from Figure 1.

The third patient who was studied following total gastrectomy was F. B., in whom the height of the plasma amino-acid nitrogen level occurred during the first hour and increased by 9.2 mg. per cent.

In two of the three patients, a steady increase in the plasma urea nitrogen levels was noted after glycine administration. No measurements of amino-acid nitrogen excretion were made in these individuals.

Thus, it would appear that patients who lack a large part or all of their stomach absorb orally administered glycine at a normal rate; furthermore, the abnormal delay of amino-acid nitrogen absorption from the intestinal tract of a patient with gastric cancer was corrected when his stomach was resected.

Discussion.—From the results obtained by means of the glycine tolerance test it appears that the absorption, and possibly the metabolism, of glycine by patients with gastric carcinoma is abnormal. Normally, the peak of the plasma amino-acid nitrogen curve occurs within one hour after the ingestion

of the glycine.[4, 7] In all the controls of the present study, with but one exception, the peak did occur within one hour. In the six patients bearing gastric cancer the peak of the amino-acid nitrogen curve occurred in the second hour. This delayed peak may be due to the presence of the neoplasm which (1) alters gastro-intestinal motility and thereby mechanically hinders amino-acid absorption; or which (2) induces a metabolic disturbance through which an abnormal amino-acid absorption results. A similar metabolic abnormality has been described in patients with sprue.[4] Moreover, the presence of marked gastric pathology (multiple peptic ulcers, diffuse Boeck's

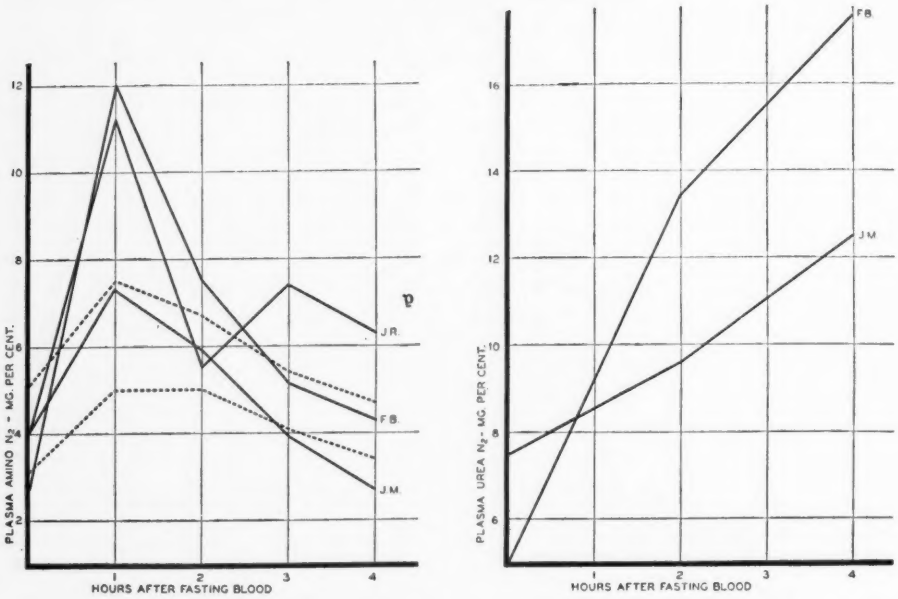

FIG. 4.—Plasma amino-acid nitrogen and urea nitrogen curves following the ingestion of 25 grams of glycine by three patients following gastrectomy. The area between the broken lines in the plasma nitrogen chart represents the control levels obtained from Figure 1.

sacoid, polypi (with follicular hyperplasia) does not appear to affect the rate of absorption of glycine from the gastro-intestinal tract.

Furthermore, after glycine ingestion the average maximum increase of the amino-acid nitrogen level (6.61 mg. per cent) in the plasma of the patients with gastric cancer, although delayed, is significantly higher than that (2.58 mg. per cent) of the six control subjects. Of the six patients with gastric cancer, five had peaks of glycine absorption higher than that of the highest control value. It has been demonstrated that the height of the plasma amino-acid nitrogen which occurs after the ingestion of glycine reflects the ability of the body to *utilize* the compound.[7] Hence, the abnormally high peak of the amino-acid nitrogen level in the plasma of patients with gastro-intestinal cancer after the glycine ingestion suggests that these individuals have not only a slow absorption of glycine but also an impaired ability to utilize that compound at a proper rate. These suggestions ap-

parently are borne out further by the observations that neither the delayed absorption nor decreased rate of utilization of the glycine by patients with gastro-intestinal cancer could be attributed to any abnormal rate of its urinary excretion. Furthermore, the *fasting* levels of amino-acid nitrogen in the plasma of these patients were within normal limits which, therefore, would indicate that the abnormalities observed were not due to the fact that the tissues of the patients were saturated with amino-acids.[8]

In summary, then, the abnormal rate of absorption and defective rate of utilization of amino-acids (glycine) by patients with gastric cancer may contribute to the high incidence of hypoproteinemia observed in these patients[1] since the production of plasma protein depends upon proper absorption and metabolism of the intermediary products of protein metabolism.

CONCLUSIONS

1. In six patients with gastro-intestinal cancer, a delayed absorption of glycine followed the ingestion of 25 Gm. of that amino-acid. This abnormality probably was due to the presence of the cancer.

2. The high peaks of plasma amino-acid nitrogen curves obtained in the patients with gastric cancer suggest a delayed rate of utilization of that compound.

3. Following removal of the stomach from a patient with gastro-intestinal cancer, a rapid, high peak of the plasma amino-acid curve was obtained. This may indicate that the presence of the carcinoma contributes to the slow absorption, but not to the impaired utilization of glycine.

4. The defective absorption and metabolism of the end-product of protein digestion in patients with gastric cancer may contribute to the hypoproteinemia state so frequently exhibited by these patients.

REFERENCES

[1] Ariel, I. M., Rekes, P. E., Pack, G. T., and Rhoads, C. P.: Metabolic Studies in Patients with Gastro-Intestinal Cancer X. Abnormalities of Protein Metabolism in Patients with Gastric Cancer. To be published.

[2] Ariel, I. M., Abels, J. C., Pack, G. T., and Rhoads, C. P.: Metabolic Studies in Patients with Gastro-Intestinal Cancer. XI. Nitrogen Balance Studies in Patients Undergoing Abdominal Surgery and the Incidence of Postoperative Hypoproteinemia in Patients with Gastric Cancer. To be published.

[3] Strauss, M. B.: The Rôle of the Gastro-intestinal Tract in Conditioning Deficiency Disease. J. A. M. A., **104**, 613–618, 1935.

[4] Erf, L. A., and Rhoads, C. P.: The Glycine Tolerance Test in Sprue and Pernicious Anemia. J. Clin. Investigation, **19**, 409-421, 1940.

[5] Van Slyke, D. D., Dillon, R. T., MacFadyen, D. A., and Hamilton, P.: Gasometric Determination of Carboxyl Groups in Free Amino-Acids. J. Biol. Chem., **141**, 627–669, 1941.

[6] Van Slyke, D. D.: Determination of Urea by Gasometric Measurements of Carbon Dioxide Formed by Action of Urease. J. Biol. Chem., **73**, 695–723, 1927.

[7] Kirk, E.: The Ability of Nephritic Patients to Deaminize and Form Urea from Ingested Glycine. J. Clin. Investigation, **14**, 136–141, 1935.

[8] Unpublished data, this laboratory.

THE TREATMENT OF POSTOPERATIVE HYPOPROTEINEMIA IN PATIENTS WITH CANCER OF THE COLON AND RECTUM*

GEORGE E. BINKLEY, M. B. (Tor.), JULES C. ABELS, M.D.,†
AND
C. P. RHOADS, M.D.
NEW YORK, N. Y.

FROM THE COLON AND RECTUM SERVICE OF MEMORIAL HOSPITAL, NEW YORK, N. Y.

THE PHYSIOLOGIC DERANGEMENT of patients with cancer of the colon and the rectum deserves careful consideration when surgery is contemplated. The ability of these patients to maintain normal levels of serum protein and a satisfactory status of liver function before and after operation are important factors in the successful treatment of their disease. There is considerable evidence to show that a persistent hypoproteinemia may result in tissue edema, ascites, altered motility of the gastro-intestinal tract, wound disruptions, and an increased susceptibility to infection.[1] The many complications that may follow major surgery in patients with liver disease is common clinical knowledge. These range from febrile reaction to sudden death from so-called liver shock.[2] Experience in our clinic has proven that many of these complications can be avoided when the patient maintains a satisfactory level of serum protein. Moreover, we feel that during the past few years, since this factor of hypoproteinemia has been given careful attention, the postoperative mortality and morbidity have been decreased (Table I).

TABLE I

OPERATIONS WITH OPERATIVE MORTALITY ON THE COLON AND RECTUM SERVICE—YEAR 1942

Type of Operation	Number of Patients	Deaths
Rectum:		
Abdomino-perineal (one stage)	55	0
Perineal Resection:		
With abdominal colostomy 8		
With perineal colostomy 2	10	0
Colostomies	54	6
Colon:		
Iliotransversecolostomy	4	0
Resection of right colon	3	0
Resection of left colon (Mikulicz)	8	0
Resection of transverse colon (Mikulicz)	1	0
Exploratory for carcinomatosis	2	1
Cecostomy	1	1

Previous investigations in this hospital of a group of patients with cancer of the esophagus, stomach, colon and rectum revealed that 58 per cent in this group were hypoproteinemic.[3] Also, in a study of 100 patients with gastric cancer, hypoproteinemia was found preoperatively in 67 per cent.[4] In the

* This investigation was undertaken with the aid of a grant from the National Cancer Institute.

† Finney-Howell Fellow.

latter group the hypoproteinemia was due chiefly to an inability of the livers of these individuals to fabricate albumins rather than to a deficiency of protein in the diet or to an increased protein catabolism.[5]

In the present communication an analysis of a group of patients with malignant neoplasms of the colon and the rectum is presented. An effort was made to determine in these patients the frequency and degree of hypoproteinemia before and after they were subjected to operation, and to suggest a type of treatment which was found to be satisfactory for this disorder.

In all, 65 patients were studied. These were selected from 100 consecutive admissions to the Rectum and Colon Service. The remaining 35 were discarded because of inadequate studies and reports. The diagnosis was proven in all instances. The tumors were located as follows: Ten in the right colon, 14 in the left colon, and 41 in the rectum or rectosigmoid. All patients were submitted to and survived operation. The procedure consisted of radical resection of the tumor in the patients considered operable, and a short-circuiting, palliative procedure in those who had reached the inoperable stage.

Determination of the serum protein was made by the falling-drop method of Weech, *et al.*[6] Levels below 6.5 grams per cent were considered abnormal.[4, 7]

In the 65 patients, hypoproteinemia was noted preoperatively in 23, or 36 per cent. This figure is lower than that found in the patients with gastrointestinal cancer[3] and also lower than that in patients with gastric cancer.[4] Apparently, the incidence and severity of the hypoproteinemia in these individuals could not be correlated with their ingestion of protein. Sixty of the 65 patients were considered to have ingested normal diets until the time of admission (Table II).

TABLE II

THE PREOPERATIVE LEVELS OF SERUM PROTEIN IN PATIENTS WITH CANCER OF THE RECTUM AND COLON

Serum Protein, Gm. per 100 Ml.	No. of Patients Preoperatively	No. of Patients on Adequate Diets	No. of Patients on Inadequate Diets or who Suffered from Diarrhea
4.6—5.0	0	0	0
5.1—5.5	3	2	1
5.6—6.0	3	3	0
6.1—6.5	17	14	3
6.6—7.0	21	18	3
7.1—7.5	18	15	3
7.6—8.0	3	3	0

It is very important to note that after operation almost all the patients with cancer of the rectum and colon became hypoproteinemic. In the first postoperative week 56 of the 65 patients (86 per cent) had abnormally low levels. Preoperative, none of these patients had concentrations of less than 5.1 grams per cent, but after operation four had these very low levels. Likewise, only three had preoperatively concentrations of from 5.1 to 5.5 grams per cent, but after operation 21 had levels in this range (Table III).

TABLE III

THE PRE- AND POSTOPERATIVE LEVELS OF SERUM PROTEIN IN PATIENTS WITH CANCER OF THE RECTUM AND COLON

Serum Protein. Gm. per 100 Ml.	No. of Patients Preoperatively	No. of Patients Postoperatively
4.6—5.0	0	4
5.1—5.5	3	21
5.6—6.0	3	21
6.1—6.5	17	10
6.6—7.0	21	6
7.1—7.5	18	2
7.6—8.0	3	1

Fifty-two of the 65 patients studied received parenteral protein therapy. Apparently, a normal level of protein cannot always be obtained and maintained by dietary nitrogen nor even by the intravenous administration of from 20 to 60 grams of amino-acids (Table IV). It has been found necessary for this purpose to use blood, plasma, and a high protein-carbohydrate diet. Whole blood was employed in most instances, since its administration

TABLE IV

THE LEVELS OF SERUM PROTEIN IN PATIENTS WITH CANCER OF THE RECTUM AND COLON, WHO RECEIVED NO PARENTERAL PROTEIN POSTOPERATIVELY

Patient	Serum Protein, Gm. per 100 Ml. Preoperatively	Serum Protein, Gm. per 100 Ml. 1st Day Postoperatively	Amount and Source of Nitrogen Postoperatively	Days of Nitrogen Source Administration	Serum Protein Level after Nitrogen Administration Gm. per 100 Ml.	Surgical Complication
F.G.....	6.2	5.4	Intravenous amino-acids, 15-60 Gm., q.d.	10	5.5	Ileus
A.E.....	6.4	6.0	Oral protein, 40 Gm., q.d.	5	5.5	
L.G.....	6.7	6.2	Oral protein,	8	5.9	
E.K.....	6.5	5.9	Intravenous amino-acids, 15-40 Gm., q.d. Oral protein, 45-70 Gm., q.d.	7	6.0	
K.D.....	6.4	5.3	Intravenous amino-acids, 30-75 Gm., q.d.	10	5.4	Marked abdominal distention
I.C.....	—	5.4	Oral protein, 40 Gm., q.d.	12	5.6	Wound disruption
B.C.....	6.4	5.9	Oral protein, 30-60 Gm., q.d.	14	5.9	
K.P.....	6.6	—	Oral protein, 45 Gm., q.d.	18	5.7	Wound disruption

not only increases the level of serum protein but also the red count and the hemoglobin content. Infusions of blood plasma were given to those patients who had hypoproteinemia unassociated with anemia. As soon as the patients could tolerate food after operation, high protein diets were used in all instances. Milk protein was given from the third or fourth postoperative day and the amount increased until the patients received about 100 grams daily. Thirty-two patients received only blood transfusions, while 20 received both whole blood and plasma. By these measures it was possible

to raise the concentrations of serum protein in 46 of the 52 patients. These increases ranged from 0.2 to 2.1 grams per cent, and the average increase was 1.6 grams per cent. All the levels finally were above 5.0 grams per cent (Table V). Fifty of the 52 patients (96 per cent) were hypoproteinemic after operation, but after the treatment described only 24, or 46 per cent, had serum protein levels below normal.

TABLE V

THE SERUM PROTEIN LEVELS IN PATIENTS WITH CANCER OF THE RECTUM AND COLON, PREOPERATIVELY, POSTOPERATIVELY, AND AFTER THERAPY

Serum Protein, Gm. per 100 Ml.	Number of Patients		
	Preoperatively	Postoperatively	After Therapy
4.6—5.0	0	4	0
5.1—5.5	2	20	3
5.6—6.0	3	17	5
6.1—6.5	13	9	16
6.6—7.0	19	2	20
7.1—7.5	13	0	6
7.6—8.0	1	0	2

Although it is essential to combat immediately the hypoproteinemia in patients subjected to surgery by the repeated administration of blood or plasma, it would not be possible to continue such procedures indefinitely. However, if the hypoproteinemia which developed after surgical manipulation was only a transitory affair, then the temporary replacement of serum protein by infusion would be feasible until that time when the patient would fabricate sufficient protein from dietary nitrogen. In order to ascertain whether or not patients with cancer of the colon and rectum eventually could depend only upon dietary nitrogen to maintain their preoperative or normal concentrations of serum protein, determinations of that substance were made in a group of 14 patients at variable periods after they had received their last infusion of blood or plasma (Table VI). With but one exception, it was found that the serum protein levels of these individuals,

TABLE VI

THE ABILITY OF PATIENTS WITH CANCER OF THE RECTUM AND COLON TO FABRICATE PROTEIN AFTER OPERATION

Patient	Serum Protein, Gm. per 100 Ml.			
	Preoperative Level	Level During First Week Postoperative	Days After Last Infusion	Level At That Time
A.W.	6.8	5.7	60	7.5
H.R.	7.8	6.4	20	6.8
J.C.	6.6	5.2	34	7.5
A.R.	6.6	5.7	150	7.0
J.F.	7.6	5.4	100	6.6
C.C.	5.3	4.8	30	6.3
J.D.	7.1	6.6	84	6.3
J.R.	6.7	5.0	23	6.6
K.D.	6.4	5.0	30	6.4
E.S.	7.0	6.2	55	6.4
A.E.	6.4	5.5	20	6.8
L.C.	7.5	5.7	22	7.1
C.D.	7.1	5.3	20	7.0
A.M.	6.8	6.1	31	6.9

from 20 to 150 days after they received their last parenteral protein, were significantly higher than the levels during the first postoperative week. Of the 14 patients, one had hypoproteinemia preoperatively; during the first postoperative week this abnormality was noted in 13; and, finally, considerably after the last parenteral protein, only four still had mild reductions of their serum protein concentrations. These observations would indicate, therefore, that the chief purpose of the measures taken in this investigation to combat postoperative hypoproteinemia was to supply enough protein during that short period when the surgical procedure might have increased protein catabolism or impaired protein fabrication.

The ability to counteract hypoproteinemia was greatly handicapped by the presence of acute infections. Of the 52 patients studied, in which the above form of treatment was instituted, six failed to obtain any increase in the serum protein level; and four of these six suffered with an acute infection. In these instances, the refractory hypoproteinemia might have been due to the effects of the infection on the liver or to additional protein catabolism. Other workers[8] have demonstrated the presence of impaired hepatic function during pneumonia, sepsis, and acute rheumatic fever.

Eighteen of the 52 patients studied had infections of the genito-urinary tract for which sulphone drugs were employed. It was noted that the amount of blood and plasma required to combat the hypoproteinemia of these individuals was greater than that needed for the patients without infections. The former group received from 500 to 3150 ml. of blood, the average being 1800 ml., while the average amount of blood required for the latter group with hypoproteinemia ranged from 250 to 2700 ml. and averaged 950 ml. The average amount of plasma was 1200 ml. for the patients with infections, and 740 ml. for those who did not develop infections. Of the 18 patients with bladder infections, four, or 23 per cent, failed to show any rise in their levels of serum protein during the first 14 days of treatment. In ten other instances, or 55 per cent, an increase of the serum protein level was noted only after the 14th day of treatment (Table VII).

TABLE VII

THE ABILITY OF INFECTION TO IMPAIR THE EFFECTS OF HIGH PROTEIN THERAPY

	Patients without Infection of the Bladder	Patients with Infection of the Bladder
Number	34	18
No serum protein rise after therapy in	6%	23%
Delayed serum protein rise (14 days or more) in	29%	55%

These findings strongly suggest that the treatment of hypoproteinemia is made much more difficult by the presence of infection, which seems to set up a vicious circle in that it induces a fall in the serum protein level, and the presence of hypoproteinemia decreases the patient's resistance.[1] In certain of these individuals with infection it may be difficult or impossible to maintain a satisfactory serum protein concentration; nevertheless, the administration of blood or plasma in these instances probably avoids the

development of dangerously low serum protein levels and consequent grave surgical complications.

CONCLUSIONS

1. The incidence of hypoproteinemia in patients with cancer of the rectum and colon was found to be 36 per cent. This incidence is increased to 86 per cent after the patients have been subjected to surgical procedure.

2. In the early preoperative period, hypoproteinemia is best treated by intravenous plasma protein. Later in the convalescence, sufficient amounts of dietary nitrogen may be ingested to counteract the postoperative hypoproteinemia.

3. It is believed that the correction of the postoperative hypoproteinemia is, in great part, responsible for the decreased mortality among patients with rectal and colon cancer.

4. The presence of infection in the patients studied considerably impairs the effectiveness of the measures outlined to combat the hypoproteinemia.

REFERENCES

1 Whipple, G. W.: Hemoglobin and Plasma Protein: Their Production, Utilization, and Interrelation. Am. J. Med. Sc., **203**, 447–489, 1942.

2 Heyd, C. G.: Mortality Factors in 4000 Operations on the Biliary System. Mississippi Doctor, **18**, 117–123, 1940.

3 Abels, J. C., Rekers, P. E., Binkley, G. E., Pack, G. T., and Rhoads, C. P.: Metabolic Studies in Patients with Gastro-Intestinal Cancer. II. Hepatic Dysfunction. Ann. Int. Med., **16**, 221–240, 1942.

4 Ariel, I. M., Rekers, P. E., Pack, G. T., and Rhoads, C. P.: Metabolic Studies in Patients with Gastro-Intestinal Cancer. X. Abnormalities of Protein Metabolism in Patients with Gastric Cancer: To be published.

5 Ariel, I. M., Abels, J. C., Pack, G. T., and Rhoads, C. P.: Metabolic Studies in Patients with Gastro-Intestinal Cancer. XI. The Postoperative Hypoproteinemia in Patients with Gastric Cancer: To be published.

6 Weech, A. A., Reves, E. B., and Goettsch, E.: The Relationship Between the Specific Gravity and Protein Content in Plasma, Serum, and Transudate from Dogs. Jour. Biol. Chem., **113**, 167–174, 1936.

7 Hill, R. H., and Trevorrow, V.: Plasma Albumin, Globulin and Fibrinogen in Healthy Individuals from Birth to Adult Life. J. Lab. and Clin. Med., **26**, 1838–1849, 1941.

8 Paulson, M., and Wyler, C. I.: Multiple Tests in Gastro-enteric Malignancy: The Value of Bromosulfalein, Hippuric Acid, and van den Bergh Reaction in Detecting Hepatic Metastases with Evaluation of Normality of Hippuric Acid Test. Ann. Int. Med., **16**, 872–878, 1942.

ACCESSORY SPLEEN IN THE SCROTUM

REVIEW OF LITERATURE ON ECTOPIC SPLEENS AND THEIR ASSOCIATED SURGICAL SIGNIFICANCE

J. M. EMMETT, M.D., AND M. L. DREYFUSS, M.D.

CLIFTON FORGE, VA.

FROM THE DEPARTMENTS OF SURGERY AND PATHOLOGY, CHESAPEAKE AND OHIO HOSPITAL, CLIFTON FORGE, VA.

THE PRESENCE of an ectopic spleen in the scrotum, simulating a testicular tumor, is a rare enough finding to warrant recording.

Case Report.—A white male, age 47, was admitted to the Surgical Service of the Chesapeake and Ohio Hospital on March 3, 1942.

About seven months previously, he had noticed, for the first time, a small lump in the right groin. It did not give him discomfort, but he was advised that he had a hernia which should be repaired.

He was known to have a diverticulosis of the colon which caused frequent attacks of abdominal pain. Otherwise, his family and personal history were irrelevant.

Both inguinal rings were patulous and a definite hernial sac protruded on the right side. A smooth, round, nontender, firm mass was found attached to the upper pole of the left testicle. It was about half as large as the testicle, which seemed normal in size and consistency. This swelling had never been noticed by the patient. *Preoperative Diagnosis:* Indirect inguinal hernia, bilateral. Tumor of left testicle.

Operation.—The right inguinal hernia was repaired; and the left scrotum was incised and the testicle delivered. The tumor was found to be attached, by a broad base, to the tunica albuginea at the upper pole close to the head of the epididymis. It was encapsulated and did not penetrate into the testicle. It was removed by sharp dissection. The testicle, the epididymis and the spermatic cord appeared normal.

Pathologic Examination.—The specimen was almost completely covered with a dense, pearly-grey, glistening capsule. It measured 4 x 3.5 x 2 cm. It was firm and elastic. The cut sections showed brownish-red tissue, with an irregular network of greyish, fine trabeculae. The microscopic sections showed normal splenic tissue, with rather small follicles, and hyperplastic red pulp. The sinuses were almost bloodless and collapsed (Fig. 1).

The patient made an uneventful recovery and was discharged three weeks after operation.

COMMENT.—Puzzling as such a location of an ectopic spleen may appear on first sight, it will be readily understood if one considers the close topographic relation between spleen and urogenital organs during early intrauterine life. The differentiation of the spleen begins in about the fourth to fifth week. It is completed in the twelfth week. During this time, the spleen is transformed from a trilobated into a single organ. It is situated between the mesonephric and the urogenital fold. The mesonephros (wolffian body) reaches its maximal cephalad extension at the time when the spleen begins to develop. The caudal migration of the genital gland begins in the eighth to tenth week. Therefore, we must place the teratogenetic period, during which portions of the spleen are transported downwards with the genital gland, between the fourth and tenth week; most probably in the sixth

to eighth week (Putschar[20]) because during this time the splenic tissue is already well developed and is still in close contact with the wolffian body. Splenic tissue then accompanies the genital gland in its descensus and is finally found in the scrotum in close association with the upper pole of the left testicle and the epididymis or, in the female, in the region of the mesosalpinx and the mesovarium. The path of this migration is, in some cases, visibly demonstrated by a band of tissue—consisting of fibrous and/or splenic tissue—which connects the normally located spleen with the ectopic spleen in the scrotum or the broad ligament. This band runs from the splenic hilus anteriorly to the intestines and ends near the testicle or the mesosalpinx. A nodule of splenic tissue has been seen, in some cases, at the distal end (Fig. 2).

Putschar[20] has collected several cases with such bands between the spleen and genital organs. Since then, another such case has been published by Fischer and Gissel[7]:

Case of Fischer and Gissel.[7]—The patient was a 13-year-old boy who was operated upon for an undescended testicle in the left inguinal canal. A flat, further upward, round band extended from the epididymis into the left side of the abdominal cavity. It was followed for 20 cm. It was as thick as a knitting needle, smooth and dark red. The lowermost 8 cm. were removed and found to consist of typical splenic tissue.

The authors express the opinion that this malformation occurs more frequently than the recorded cases would indicate but that it is either erroneously interpreted or not published.

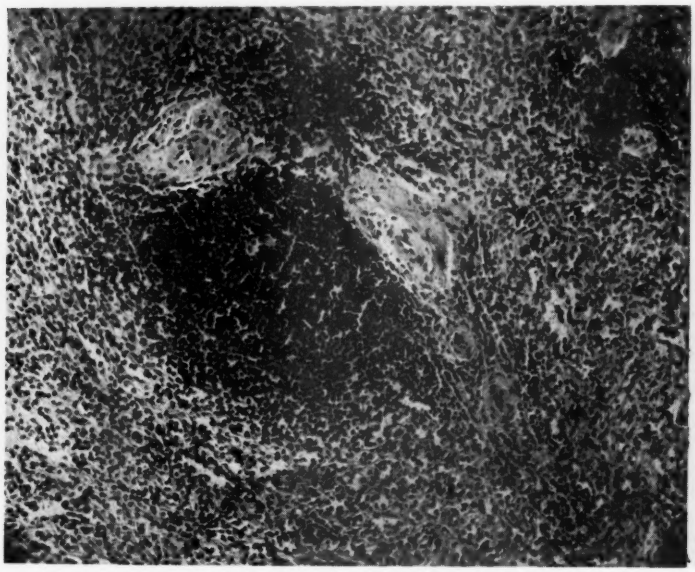

FIG. 1.

FIG. 2.

FIG. 1.—Photomicrograph of section from paratesticular tumor showing characteristic splenic tissue.
FIG. 2.—Band of splenic tissue connecting the normally located spleen, with an accessory spleen in the scrotum. (Redrawn from Sneath.[23])

The literature contains, in addition, several reports of cases in which—like in our own case—the ectopic spleen in the scrotum was not connected with the spleen.

Case of Finaly.[6]—The patient was a male newborn child with a congenital left inguinal hernia. The left testicle seemed twice as large as the right and had a different shape. A dark brown and purple, round swelling at the head of the epididymis was removed. It was covered with peritoneum and consisted of splenic tissue.

Case of Talmann.[24]—The patient, a 22-year-old soldier, had a painful swelling in his left scrotum. During malarial attacks this swelling reached the size of a goose egg. One nodule of splenic tissue, 2.5 cm. in diameter, was found at the head of the left epididymis, another, 0.4 x 0.5 x 0.8 cm., was present in the spermatic cord.

Case of Osseladore.[17]—The patient, a 19-year-old white boy had, since birth, three nodules in his left scrotum which had grown corresponding to the body development. The largest nodule suggested at the time of operation, as to size and consistency, a third testicle. The two smaller ones were pedunculated. All three consisted of splenic tissue which was, in places, sclerotic and contained several iron-calcium deposits.

Case of Settle.[22]—The patient, an adult, suffered from a painful enlargement of the left testicle during the acute febrile phases of a tertian malaria. An enlarged accessory spleen was found in the scrotum.

Even these few cases illustrate the almost impossible task of a correct preoperative diagnosis. Probably the true condition will only be recognized after microscopic study. However, in the presence of a long-existing tumefaction of the left testicle, particularly when accompanied by an inguinal hernia, the possibility of an ectopic spleen should be considered in the already difficult diagnosis of testicular tumors. (The painful periodic swelling associated with malarial attacks in the cases of Settle,[22], and Talmann,[24] might perhaps have led to hazarding a tentative diagnosis).

Although it was not possible to inspect the spleen in the present case, we may conclude, from the other similar reports, that a normal spleen was present in normal location. Thus, we would list this case of scrotal spleen among the accessory aberrant) spleens. A certain confusion prevails as to the correct nomenclature of spleens in anomalous location. A clear distinction should be made between the following types: (1) Wandering spleen. (2) Double spleen. (3) Multiple spleen. (4) Accessory (aberrant) spleen. These types differ from each other in their formal genesis as well as in their clinical significance.

The wandering or floating spleen is the type most frequently involved in surgical complications. Since Abell[1] reported 95 cases of wandering spleen, with torsion of the pedicle, additional publications have brought the total to about 120. The wandering spleen may be found in any part of the abdominal cavity and—as in ventral or diaphragmatic hernia—even outside the abdomen. It is much more frequent in women than in men, and its incidence is especially high in multiparae. Only three cases have been reported in children (Truesdale and Freedman[26]). It is, therefore, assumed that the relaxation of the abdominal wall plays an important part in the causation of the displacement, although this is probably not the only factor involved. Minor, easily overlooked disturbances of peritoneal development, and consequent faulty attachment of the organ, are most likely equally responsible. The relative frequency

with which wandering spleen is found in malaria, is unexplained. The weight of these spleens is far below that found in leukemia, Banti's or Gaucher's disease, and no case of wandering spleen associated with any of these conditions has been observed.

Symptoms usually are due to torsion of the vascular pedicle. The symptomatology varies according to the location of the spleen and is that of the torsion of the pedicle of an intra-abdominal tumor. Transitory attacks of colicky pain have occasionally occurred preceding the final attack.

Only in rare instances, has the wandering spleen, as such, caused complications which necessitated surgical relief or interfered, after torsion had occurred, with the function of other organs. A wandering spleen in the pelvis acting as an obstetric impediment has been described by Ottow.[18] Intestinal obstruction has been reported by Mauro,[15] Pacchini,[19] Salvin,[21] and Harris.[10] Cases of gastric volvulus have been published by Lamarque, *et al.*,[13] Bertone,[5] and Zhdanovich.[28] A wandering spleen was the cause of chronic dyspepsia in the case of Hjort.[11]

Splenectomy is the only method of treatment. Conservative measures, as attempting to untwist the pedicle, are contraindicated. The results are satisfactory, although the mortality rate in pregnant women is considerable.

Double spleen is exceedingly rare. In this condition, two, as to size and shape, equivalent spleens are found in place of the single organ. A discussion as to the origin of this malformation is beyond the scope of this paper. The reader is referred to the monograph of Putschar.[20] The literature contains no reference of double spleens of clinical significance.

We speak of multiple spleen when we find, instead of a single spleen, a varying number of small spleens (3–10) in the left hypochondrium or scattered over the visceral or parietal peritoneum of the entire abdominal cavity (up to 400). They may be due to faulty development of the multiple splenic anlage or to multiple autotransplants after a (intra-uterine) trauma to the spleen. Krueger and Mast,[12] and Hambrick and Bush,[9] have recently described multiple splenic implants after splenic injury and splenectomy, and have reviewed the literature. The multiple spleens are of little clinical significance. However, Leriche and Gravier[14] have reported the torsion of the pedicle in one of several multiple spleens, complicated by rupture and intra-abdominal hemorrhage, and treated by multiple splenectomy.

By far the most frequent type are the accessory (aberrant, supernumerary) spleens in the presence of a normally formed spleen in correct position. They are found in about ten per cent of all autopsies. Their number varies, and is rarely over 40. Most of them are found in the immediate neighborhood of the spleen but they are encountered also in the upper omentum, the gastrocolic ligament, the mesocolon, and in the pancreas. Only very rarely are they seen in other intra-abdominal locations or in the scrotum. Their size varies from that of a pinhead to four centimeters in diameter. They are usually sessile but some are pedunculated. They rarely produce clinical

symptoms by torsion of the pedicle (Alexander,[2] and Alexander and Romanes,[3] Geiger,[8] and Settle[21]) or cause intestinal obstruction (Bainbridge,[4] Voss,[27] and Temoin[25]) or both (Settle[22]). A curiosity is the case of Morris, Lederer and Fradkin.[16] Their patient had his spleen removed for thrombocytopenic purpura. A walnut-sized accessory spleen was left in the abdomen. The patient was well only for a short while but then the blood dyscrasia returned due to the action of the accessory spleen. Considerations along this line would make the search for accessory spleens important, also, where splenectomy for hemolytic jaundice is performed.

SUMMARY

A case of accessory spleen in the scrotum is reported and the genesis of the malformation discussed. Similar cases in the literature are summarized. The various types of spleens in anomalous location are surveyed and their clinical importance evaluated.

BIBLIOGRAPHY

1 Abell, I.: Wandering Spleen with Torsion of Pedicle. ANNALS OF SURGERY, **98**, 722–735, 1933.

2 Alexander, R. Ch.: Accessory Spleen with Recurring Torsion of its Pedicle. Lancet. **217**, 17, 1929.

3 Alexander, R. Ch., and Romanes, A.: Accessory Spleen Causing Acute Attacks of Abdominal Pain. Lancet, **2**, 1089–1091, 1914.

4 Bainbridge: Quoted by Putschar.[20]

5 Bertone, C.: Occlusione e turbe funzionali dello stomaco e dell' intestino da ectopia splenica o da tumore di milza. Riforma Medica, **50**, 765–770, 1934.

6 Finaly, R.: Bijmilt aan de epididymis in een aangeboren liesbruek bij een zuigling. Nederl. Tijdschr. Geneesk., **2**, 397–400, 1926.

7 Fischer, W., and H. Gissel: Ein eigentuemlicher Operationsbefund: Milzgewebsstrang zum Nebenhoden ziehend. Brun's Beitr. z. klin. Chir., **161**, 595–598, 1935.

8 Geiger, Ph.: Ein Fall von stielgedrehter Nebenmilz. Zentralbl. f. Chir., **58**, 1772, 1931.

9 Hambrick, R. A., and Bush, J. D.: Autoplastic Transplantation of Splenic Tissue in Man, Following Traumatic Rupture of the Spleen. ANNALS OF SURGERY, **115**, 84–92, 1942.

10 Harris, H. A. H.: Case of Wandering Spleen Causing Intestinal Obstruction. Brit. J. Surg., **15**, 163–165, 1927.

11 Hjort, E.: Wandering Spleen with Dyspeptic Symptoms. Med. Rev. Bergen, **53**, 321–324, 1936.

12 Krueger, J. T., and Mast, H. E.: Splenic Transplants Following Traumatic Rupture of Spleen and Splenectomy. Am. J. Surg., **58**, 289–293, 1942.

13 Lamarque, P., Morgue-Molines, E., Betoulieres, P., and Ginestié, J.: Volculus gastrique et sténose colique secondaires a une ectopie pelvienne de la rate. Arch. d' électric. med., **46**, 107–115, 1938.

14 Leriche and Gravier: Rates multiples en position droite inter-hepato duodeno-colique; volvulus d'un des pedicules: éclatement d'une des rates; hemorragie intraperitoneale; laparotomie; splencctomies multiples; guérison. Lyon Chir., **19**, 107, 1922.

15 Mauro, M.: Due casi di milza malarica ectopica e torta sul pedunculo complicati da occlusione intestinale meccanica. Riforma Med., **50**, 1153–1158, 1934.

16 Morrison, M., Lederer, M., and Fradkin, W. Z.: Accessory Spleens: Their Significance in Thrombocytopenic Purpura Hemorrhagica. Am. J. Med. Sci., **176**, 672–681, 1928.

17 Oselladore, G.: Milze succenturiate annesse al testicolo. Arch. ed atti d. Soc. Ital. di Chir., **35,** 754–758, 1929.

18 Ottow, B.: Eine dystope im Douglas gelegene Milz als Geburtshindernis: Extirpation in der Schwangerschaft. Zentralbl. f. Gynaek., **60,** 1107–1110, 1936.

19 Pachinni, P.: Ptosi splenica e sindrome occlusiva intestinale. Policlinico, sez. prat., **29,** 905–908, 1922.

20 Putschar, W.: Die Entwicklungsstoerungen der Milz: in H. Schwalbe's Morphologie der Missbildungen des Menschen und der Tiere. Vol. **3,** 760–856, G. Fischer, Jena, 1934.

21 Salvin, A. A.: Ectopic Spleen Causing Intestinal Obstruction. ANNALS OF SURGERY, **92,** 263–269, 1930.

22 Settle, E. B.: The Surgical Significance of Accessory Spleens. Am. J. Surg., **50,** 22–26, 1940.

23 Sneath, W. A.: An Apparent Third Testicle Consisting of a Scrotal Spleen. J. Anat. & Physiol., **47,** 340–342, 1912–13.

24 Talmann, J. M.: Nebenmilzen im Nebenhoden and Samenstrang. Virchow's Arch., **259,** 237–243, 1926.

25 Temoin, D.: Rate accessoire simulant au néoplasm de l'intestin. Arch. provinc. de Chir., **7,** 622, 1898.

26 Truesdale, P. E., and Freedman, D.: Wandering Spleen with Torsion of Pedicle. Surgery, **4,** 700–707, 1938.

27 Voss, P.: Accessory Spleen Associated with Chronic Intestinal Obstruction. Austral. & New Zealand J. Surg., **3,** 287–288, 1934.

28 Zhdanovich, S. N.: Volvulus of Stomach Caused by Torsion of Dislocated Spleen. Vestnik Khir., **34,** 157–158, 1934.

SPONTANEOUS RUPTURE OF THE URINARY BLADDER*

REPORT OF CASE OF SECOND RUPTURE

WILLIAM BERRY MARBURY, M.D., AND LT. COMDR. WESLEY FRY, M.C.
WASHINGTON, D. C.

THERE has been considerable discussion as to what constitutes a "spontaneous" rupture of the urinary bladder. Some authors[1, 2, 3] have preferred to designate nontraumatic ruptures as "idiopathic" when there was no apparent pathology in the bladder, and as "pathologic" when there was. Sisk and Wear[4] attributed the confusion in terminology to the fact that the word, "spontaneous," has not been accepted in its proper sense; that is, as proceeding from an internal impulse, without external force. They contended: "If the bladder ruptures without external stimulation, it is spontaneous and deserves to be reported as such." Cases which have recently been reported as spontaneous ruptures have included both those caused by overdistention from obstruction and those caused by a pathologic condition of the bladder wall, either of primary or of secondary origin. Thus, the use of the term now seems established to include all nontraumatic ruptures of the urinary bladder.

That spontaneous rupture is a rare condition is shown by the fact that Besley[5] found only one spontaneous rupture among 23 cases of ruptured bladder at the Cook County Hospital. Baumer[6] listed 27 cases of nontraumatic rupture, which he had found reported in the literature during the fourteen years preceding 1913. Stone[7] stated that up to 1931 only 40 cases had been reported. He reported two additional cases. These series do not appear to include cases of spontaneous rupture during pregnancy nor those due to an extension of a tubo-ovarian abscess. Up to 1941, 34 cases of the former had been reported and 58 of the latter condition.

As far as we have been able to determine, the following case of a second spontaneous rupture of a urinary bladder is the only one of its kind to have been reported.

Case Report.—C. M., white, male, age 37, was admitted to Emergency Hospital, March 19, 1941, complaining of pain in the abdomen. Twenty-four hours before admission he had been taken with a severe abdominal pain, which gradually increased in intensity. He had vomited twice during the 24 hours. The patient stated that for the previous week he had been drinking from one and one-half to three pints of whiskey a day. He also said that when he was age 25 he had begun drinking periodically, at intervals varying from a few months to eight months, and with drinking periods lasting from 10–14 days. In 1930 he was treated for lues and had received injections for 14 months.

The patient had had a previous admission to Emergency Hospital, November 14, 1940, because of abdominal pain and an inability to void, following a two-weeks' period

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of drinking. His spinal fluid had shown a positive Wassermann and a colloidal gold curve of 1111100000. At that time a diagnosis was made of "urinary retention of undetermined etiology; possible cord bladder."

In April, 1940, eight months prior to his first admission to Emergency Hospital, he had had a rupture of the urinary bladder, following an alcoholic debauch. He was operated upon at the West Jersey Homeopathic Hospital, and about 1,000 cc. of urine was evacuated from the abdomen. Exploration revealed that the urinary bladder was ruptured on its posterior surface, and that the posterior wall was extremely thin at several points. The bladder was drained by a large rubber tube, and two large cigarette drains were placed in the pelvis, one on each side of the bladder. A biopsy of the bladder wall showed "papillary cystitis." A blood Wassermann was negative. A roentgenogram of the chest was negative. The patient remained in the hospital for 69 days, from April 1 to June 8, 1940.

At the time of his second admission to Emergency Hospital, his temperature was 98.6°F., pulse 78, respirations 20. Upon examination, it was noted that the pupils did not react to light but that they did to accommodation. The reflexes were normal and the Babinski test was negative. There were no sensory disturbances. The chest was normal. The abdomen was somewhat distended and rigid. There was dullness in both flanks. An examination of the urine was essentially negative, except for the presence of an occasional red blood cell. An examination of the blood showed a white cell count of 17,700 of which 93 per cent were polymorphonuclears and 6 per cent lymphocytes. A spinal Wassermann was negative, and the colloidal gold curve was 0000000000. In spite of the patient's previous history, the possibility of a rupture of the bladder was not seriously considered. It was thought that he had a ruptured duodenal ulcer. Operation was advised but was refused. Permission for operation was given eight hours later.

Operation.—Under spinal anesthesia, a right rectus incision was made and a careful exploration of all the abdominal viscera undertaken. The abdominal cavity contained about 1,000 cc. of clear fluid, apparently urine, as it had an ammoniacal odor. There was a perforation in the fundus of the urinary bladder, to the left of the midline. The opening was about one centimeter in diameter, and through it a stream of urine was spouting from the bladder. There was only a moderate peritonitis present, with a number of filmy adhesions between loops of the bowel. The fluid contents of the peritoneal cavity were aspirated, and the rent in the bladder repaired with two layers of Dulox sutures. The abdomen was closed in layers, without drainage. A retention catheter was inserted into the bladder through the urethra.

During the first three of four days after the operation, the patient received oxygen nasally, fluid intravenously, and one blood transfusion. On the second postoperative day his temperature was 104.6°F., and on the eighth day it was normal. From then on he made an uneventful recovery. On the tenth postoperative day, Dr. H. N. Dorman made a cystoscopic examination and found no pathologic condition of the bladder. The patient was discharged against advice on the twelfth postoperative day. He has been seen since his discharge and was found to be in good condition.

COMMENT.—In the foregoing case, both of the ruptures were spontaneous and both involved the posterior wall of the fundus, although the second rupture was in a different location from the first one. There was no apparent pathology in the bladder wall, and no history of injury. The etiologic factors cannot be determined definitely, but it is possible that the ruptures were associated with a luetic condition and acute alcoholism. There are numerous reported cases of bladder rupture occurring during a period of alcoholism, but

in these cases the immediate cause of the rupture was traumatic, either concussional or penetrative.

The most frequent cause of spontaneous rupture is hyperdistention of the bladder wall. The overdistention arises from an obstruction to the urinary outflow, usually due to an unrelieved stricture of the urethra. Less often the obstruction is due either to pressure upon the urethra from an enlarged prostate or to a blockage of the tract by a stone. Gross retention of the urine with intramural tension may result from a neurogenic dysfunction of the bladder wall. Wilson[8] has reported an unusual case of spontaneous rupture due to cord bladder in a patient having tabes dorsalis. His case is somewhat similar to the one being reported in that both patients had syphilis. In Wilson's case, hyperdistention was caused by syphilitic damage to the accessory tracts proximal to the column of Burdach, through which passes the afferent arm of the reflex governing the tone of the musculature and sphincter of the bladder. The consequent loss of tone of the musculature and the increased tone of the sphincter amounted to obstruction at the bladder neck. At operation, performed within a few hours after the onset of symptoms, a large hole was found in the bladder wall, permitting the introduction of three fingers into the cavity of the bladder. The defect in the bladder wall was sutured in layers. The bladder and the peritoneal cavity were drained. The patient died on the second postoperative day.

The cases of spontaneous rupture which are not caused primarily by hyperdistention usually result from morbid changes within the bladder wall. Degeneration of the musculature, appearing as areas of fibrosis or necrosis, are in some instances a secondary result of chronic distention. Baumer[6] reported a case of a 58-year-old man who had an hypertrophied prostate and a history of early gonorrhea. At autopsy, the bladder wall showed a severe cystitis and multiple areas of necrosis in the hypertrophic musculature. Pathologic changes within the wall of the bladder may result from primary diseases of the bladder, such as carcinoma, ulceration, diverticula, tuberculosis, or syphilis. The bladder wall may also be affected by the extension of an adjacent neoplastic or inflammatory mass. A fistulous connection between the bladder and the inflammatory mass may be established, resulting in an extravasation of the urine. Stone[7] reported such a case. A girl, nine years of age, who four years previously had had a nontuberculous osteomyelitis of the right hip, developed pain in the right hip accompanied by a rise in temperature. Three weeks later there was a sudden onset of micturition, burning, spasm, and extreme dysuria. The urine was loaded with pus. A few days later an abscess of the right hip was incised and evacuated. Ten days later the dressing was saturated with urine. A cystoscopic examination revealed a circular opening, about two centimeters in length, in the wall of the bladder, posterior to the right ureteral orifice. Within six hours after the cystoscopic examination, the patient had urinated. Within a few weeks the sinuses in the hip closed, and the patient made a good recovery. Castallo

and Fetter[9] have recently reported a case in which an extension of a tubo-ovarian abscess penetrated the bladder wall. Falk and Hochman[10] (1939) collected 54 similar cases from the literature and reported three personal cases. In many of the cases the inflammatory mass was of gonorrheal origin.

A pathologically weakened bladder wall is predisposed to rupture. Cases are on record in which the immediate cause of the rupture was a sudden forceful contraction of the anterior abdominal wall muscles or a sudden increase in the intra-abdominal pressure. Probably a normal, unobstructed bladder does not rupture from muscular contraction, except during pregnancy. The violent contractions of the abdominal muscles in the labor of childbirth has been the responsible factor in a few reported cases.

Torpin,[11] in 1940, reviewed the published cases of spontaneous rupture of the urinary bladder in pregnancy and labor and reported a personal case. He found some eight cases associated with retroverted incarcerated pregnant uterus at three or four months. He classified the cases of spontaneous rupture in parturition as those in which (1) rupture occurred immediately; (2) rupture was delayed; (3) rupture into the vagina resulted in a vesicovaginal fistula; and (4) bladder rupture complicated uterine rupture. He cited two cases in which the bladder ruptured spontaneously during labor and four cases in which the bladder ruptured on the fourth to the tenth postpartum day. An additional case of the latter kind has since been reported by Claye[12] (1941). Torpin found one case in which the bladder ruptured into the vagina, resulting in a vesicovaginal fistula, and he reported a similar case of his own. His patient had had a vesicovaginal fistula since the birth of her fourth child, two months previous to the time he had examined her. During those two months her urine flowed from the vaginal orifice. At operation extensive lacerations were found, the anterior vaginal wall and the posterior bladder wall having been laid open in the midline from above the trigone down to the urethral sphincter. Reparative procedures were carried out, and the patient made a good recovery. Torpin based his discussion of the reported cases of urinary bladder rupture complicating uterine rupture on a series of 52 cases collected from the literature by Hagenbuck,[13] in 1925. He considered that many of Hagenbuck's cases were traumatic but that possibly 17 were spontaneous ruptures.

Spontaneous rupture of the bladder is divided into two classes, according to whether the rupture is intra- or extraperitoneal. The former is much more frequent and at the same time is far more grave. Among the 20 cases of spontaneous rupture which Sisk and Wear[4] found reported in the literature between the years 1900 and 1929, only four were extraperitoneal. Morbid changes in the bladder wall are a frequent finding in the extraperitoneal type, and an infrequent finding in the intraperitoneal type.

The symptoms and physical signs will vary depending upon whether the rupture is intra- or extraperitoneal. In the latter type the onset will be insidious, with few signs of shock. A bagginess will be noticed above the

pubis and in the groins, at times extending as high as the umbilicus. The patient will be able to void small amounts of urine, which will show some blood. In the intraperitoneal type of rupture the onset will be more sudden, and there will usually be early signs of shock. The later symptoms will be mainly those of peritoneal irritation; that is, severe abdominal pain, nausea and vomiting, and abdominal distention, rigidity and tenderness. A history of marked distention with a sudden collapse of the bladder can often be elicited. The patient will have an urgent desire to urinate, but will usually be unable to void more than a few drops. The evacuation of a very small or very large quantity of bloody urine by catheter is a significant early finding.

In the diagnosis of both types of rupture, the presence of urinary obstruction is an important indication of rupture. A cystoscopic examination is not practical, as a ruptured bladder can rarely be visualized. A cystogram taken after the injection of either iodized oil or air will sometimes reveal the point of leakage. The diagnostic test of introducing a measured amount of fluid into the bladder and comparing this amount with the quantity recovered is not infallible. When the rupture in the bladder is large, a great deal more fluid may be recovered than has been put in. If the disproportion either way is great and the urine is bloody, a rupture may be suspected.

The treatment of both intra- and extraperitoneal rupture is immediate operation. Early operation gives a very low mortality rate. Adequate urinary drainage is a most important measure in both types of rupture. In the treatment of the extraperitoneal rupture, drainage should be provided by means of a suprapubic tube. Closure of the bladder rent is not necessary, but it is certainly a desirable procedure if the condition of the patient permits its being carried out. Healing will be rapid, provided the drainage is adequate. In the treatment of the intraperitoneal rupture, the abdomen should be opened, the fluid contents aspirated, and the peritoneal cavity closed without drainage. The perforation in the bladder should be closed in layers. Urinary drainage should be provided by an indwelling urethral catheter or by a suprapubic tube, preferably the former.

The prognosis is good in the extraperitoneal type of rupture. According to Dittrich,[14] among the untreated cases of extraperitoneal rupture, only 27 per cent are fatal. The outlook in the intraperitoneal cases becomes grave after the first 24 hours. The cause of death is either peritonitis or uremia, or both.

SUMMARY

1. The term, spontaneous rupture of the urinary bladder, is now the accepted designation for all nontraumatic ruptures of the bladder.

2. Spontaneous rupture is relatively rare, comprising about four per cent of the reported cases of bladder rupture.

3. A case is reported of a second spontaneous rupture of the posterior fundus of the urinary bladder. This case seems to be the only one of its

kind to be reported. The patient was an alcoholic, with a history of having been treated for syphilis. The etiology is obscure. At operation, the rent in the bladder wall was sutured and adequate drainage of the bladder was provided. The patient recovered.

4. The most frequent etiologic factors in bladder rupture are: (1) Hyperdistention from obstruction; (2) degenerative changes in the bladder wall from chronic distention; (3) pathologic changes in the musculature due to diseases of the bladder or to the extension of neoplastic or inflammatory diseases in adjacent structures.

5. The symptoms and physical signs vary, depending upon whether the rupture is intra- or extraperitoneal.

6. In the treatment of both types of rupture, early operation and the establishment of adequate urinary drainage are imperative.

7. The prognosis in intraperitoneal rupture becomes grave if operation is delayed longer than 24 hours.

REFERENCES

1 Rivington, Walter: Rupture of the Urinary Bladder. (Hunterian Lecture). Med. Press and Circular, **II**, 434–436, November *22*, 1882.

2 Houel, Charles Nicholas: Des plaies et des ruptures de la vessie. Paris, Germer-Bailliere, 1857.

3 Goldenberg, Theodor: Beitrag zur Pathologie der Harnblasen-rupturen. Beitr. z. klin. Chir., **61**, 350–371, January, 1909.

4 Sisk, Ira R., and Wear, John B.: Spontaneous Rupture of the Urinary Bladder. J. Urol., **21**, 517–521, April, 1929.

5 Besley, Frederic A.: Rupture of the Urinary Bladder: Report and Analysis of Twenty-three Cases from the Records of Cook County Hospital. Surg., Gynec. and Obst., **4**, 514–532, April, 1907.

6 Baumer, K.: On Spontaneous Rupture of the Bladder. Thesis, University Leipzig, 1913.

7 Stone, Eric: Spontaneous Rupture of the Urinary Bladder: Report of Two Cases. Arch. Surg., **23**, 129–144, July, 1931.

8 Wilson, Leonard L.: Spontaneous Rupture of the Urinary Bladder in a Tabetic Patient. Med. Bull. Vet. Admin., **17**, 93–95, July, 1940.

9 Castallo, Mario, and Fetter, Theodore R.: Perforation of Tubo-ovarian Abscess into the Urinary Bladder: Report of a Case. Urol. and Cutaneous Rev., **55**, 425–427, July, 1941.

10 Falk, Henry C., and Hochman, Samuel: Rupture of Pelvic Inammatory Masses into the Urinary Bladder. Am. J. Obst. and Gynec., **38**, 654, October, 1939.

11 Torpin, Richard: Spontaneous Rupture of the Urinary Bladder in Labor: Case Report, Literature, and New Classification. Urol. and Cutaneous Rev., **44**, 553–557, September, 1940.

12 Claye, A. M.: A Case of Puerperal Retention of Urine Causing Traumatic Rupture of the Bladder and Death. J. Obst. and Gynec. Brit. Empire, **43**, 235–238, April, 1941.

13 Hagenbuck, M.: Über Uterusrupturen mit Blasenriss im Anschluss an eigenen Fall. Ztschr. f. Geburtsh. u. Gynak., **39**, 211–228, 1925.

14 Dittrich, Rudolf: Über spontane Harnblasen-rupturen. Deutsche med. Wchnschr., Leipz. u. Berl., **48**, 974–975, July 21, 1922.

PREOPERATIVE SCRUBBING IN ABDOMINAL SURGERY

II—CLINICAL STUDIES

J. K. BERMAN, M.D.

INDIANAPOLIS, INDIANA

FROM THE DEPARTMENT OF SURGERY, INDIANA UNIVERSITY SCHOOL OF MEDICINE, AND THE SURGICAL SERVICES OF THE UNIVERSITY HOSPITALS, INDIANAPOLIS, IND.

IN A PREVIOUS COMMUNICATION[11] we reported the effects of preoperative scrubbing as a protective measure in the prevention of wound infection when tried in experimental animals. It was found to have some value when done 96 to 120 hours before surgery. It was, perhaps, deleterious when done 12 to 24 hours before operation. This study is herewith continued in patients.

In the Indiana University Hospitals most patients are prepared for abdominal surgery as follows: On the night before operation the abdomen is shaved, scrubbed with soap and water on gauze and painted with tincture of merthiolate. Sterile towels are placed over the field and secured with adhesive tape. The incidence of postoperative wound infection has been extremely low with this routine.

By preoperative scrubbing we mean any preparation up to 12 hours before operation. Immediate surgical sterilization is not included in this study. Preoperative "scrubbing" in the University Hospitals is not done in the surgical sense. It is carried out in the manner described, without regard to the length of time or the use of a brush, and must be regarded as a cleansing process only.

The effect of scrubbing, as defined, is difficult to prove clinically. Therefore, patients with intestinal fistulae were selected because there could be no doubt of contamination at the time of surgery or shortly thereafter. Five patients with intestinal fistulae from various causes were selected for this study.

CASE REPORTS

Case 1.—A female, age 37, was admitted to the Long Hospital complaining of a fecal fistula in an old operative scar. She had been operated upon elsewhere for "pelvic infections." The abdominal wall was excoriated and bathed with intestinal content. The diagnosis was postoperative intestinal fistula of the small bowel. The patient was placed on a Bradford frame in the prone position for two weeks. This permitted the excoriated skin to heal.

Four days before operation the abdominal wall was scrubbed with soap and water for ten minutes. Immediately before operation the abdomen was again scrubbed with tincture of green soap and sterile water and washed with 70 per cent alcohol (by weight), as described by Price.[1, 2] The operation was extensive, requiring multiple resections of the small bowel, with anastomoses. The abdominal wound was closed as follows: No. 00 chromic catgut in the peritoneum (interrupted mattress), No. 000 in the muscle (interrupted), No. 00 chromic catgut in the fascia (figure-of-eight

stitch), and interrupted silk stitches in the skin, leaving about a one-quarter-inch gap between the edges. All the suture lines healed *per primam* except the skin which healed by second intention although there was a minimal amount of infection.

Case 2.—Mrs. N. F., a white female, age 36, had suffered from chronic ulcerative colitis for about eight years. Medical treatment had failed to control the course of the disease. An ileostomy was performed in November, 1941. Three weeks later the ascending, transverse and descending colon down to the sigmoid was removed. A wound infection due to colon bacilli developed four days postoperative, and an abscess formed, which was drained. However, she continued to pass blood and mucus per rectum. She was admitted to the Long Hospital for a third-stage operation in April, 1942.

Five days before surgery the abdomen was scrubbed with soap and water for eight minutes. The operation was performed April 28, 1942. Immediate preparation

FIG. 1.—Case 2: Abdomino-perineal resection showing ileostomy and surgical wound on the 8th postoperative day. The incision has healed *per primam.*

of the abdomen was exactly as in the previous case. An abdomino-perineal resection was performed, removing all of the remaining colon, rectum and anus. The wound was closed as in Case 1 except that the skin and subcutaneous tissue were closed snugly. The wound was protected with adhesive which was covered with zinc oxide ointment. However, some fecal drainage seeped under the dressing. On the eighth postoperative day stitches were removed. The wound had healed *per primam* (Fig. 1).

Case 3.—Mrs. A. H., a white female, age 41, had a pelvic operation elsewhere in 1938 for what she described as "pus tubes." One week postoperative she developed a persistent diarrhea and fecal drainage from her abdominal incision. This continued to drain and, three months later, a second operation was performed in an effort to close the fecal fistula. At this time she was having chills and fever. Smears and sections were taken from the fistula but no tuberculous or fungus infection was found. Although closure was effected, the fistula recurred and, April 30, 1940, a third operation was performed in an effort to close the fistula. On November 15, 1940, the wound again began to drain fecal material and, in addition, the same material was found to be draining from the vagina. She was admitted to the Long Hospital for diagnosis and treatment. Careful study and roentgenologic examination with iodized oil

injection revealed multiple communicating fistulae. On June 30, 1941, a left inguinal colostomy was established. The patient did not return for treatment until July 15, 1942. At this time a lipiodol injection and roentgenologic study showed a fistulous tract which communicated with the sigmoid, the bladder, the vagina and the anterior abdominal wall.

Four days prior to surgery the abdominal wall was scrubbed with soap and water for eight minutes. On the night before operation the abdomen was again scrubbed with soap and water for three minutes. Immediate preparation before surgery was exactly as in the first patient. The fistulous tracts were completely excised, and the abdominal wall was closed without drainage. One Penrose drain was brought through the posterior cul-de-sac into the vagina. The operation was successful, and the abdominal wound healed *per primam*, without infection.

Case 4.—K. W., a white female, age 54, was admitted to the Long Hospital, July 1, 1942, with a diagnosis of intestinal obstruction. She had had a pelvic operation 12 years previously. The diagnosis of intestinal obstruction was confirmed and she was operated upon. At operation, a band of adhesions was encountered extending from a loop of small bowel to the right broad ligament. Beneath this band 97 cm. of small intestine had become strangulated and was gangrenous. It was resected and both ends of the bowel were anchored to the peritoneum and secured in the manner of a double-barrel enterostomy. The abdominal wall became excoriated after two weeks. The patient was placed upon a Bradford frame in the prone position. All excretions were collected in a bed pan placed beneath the enterostomy stoma. The excoriation became greatly reduced.

Four days before the second operation for the closure of the enterostomy, the patient was scrubbed for eight minutes, in the manner previous described. On July 27, 1942, the wound was reopened and the ends of the bowel freed, inverted, and brought together by a lateral anastomoses. The peritoneum was closed with chromic No. 00 catgut and everted with interrupted mattress sutures. The muscle was brought together with interrupted sutures of the same material. The fascia was closed, with the same material, by an interrupted cross-stitch, with buried knots. The subcutaneous tissue was loosely approximated with No. 000 chromic catgut and a one-quarter-inch gap was allowed between the edges of this tissue. The skin was held with interrupted silk and it, too, was allowed to gape one-quarter inch. The skin edges remained apart although there was a minimal amount of infection.

Secondary closure was undertaken under one per cent novacain anesthesia. The skin was cleansed with soap and water and washed with sterile normal saline solution, then brought together with interrupted silk sutures. The wound healed *per primam.*

Case 5.—J. L., a female, age 26, was admitted to the Long Hospital in July, 1942, with the history that in September, 1940 a pelvic operation was performed elsewhere; 15 days after the operation the incision opened and drained fecal matter; and this had persisted up to the time of admission. The diagnosis was postoperative fistula of the small bowel.

The abdomen was scrubbed four days before the operation, as had been done in the previous four cases. Immediate preparation was exactly as in Case 1. At operation, the fistula was excised and found to communicate with a loop of ileum. The opening into the bowel was trimmed away and turned in with silk sutures. The abdominal incision was washed with normal salt solution and was closed without drainage. The wound healed *per primam.*

This study leads us to believe that stitch, subcutaneous and skin infections, generally, are less common in the repair of abdominal fistulae with preliminary scrubbing of the abdominal wall four days before operation, if attention is given to other factors in the healing of contaminated wounds. These factors are (1) the avoidance of excessive trauma; (2) washing of the wound with

1000 cc. of sterile normal saline before closure; and (3) incomplete closure of the skin and subcutaneous tissue. Perhaps it is the local immunity that develops due to the constant presence of bacteria which aids in the healing *per primam* in most of these cases. However, this was not as apparent prior to our scrubbing technic. There have been no patients with dehiscence of the wound since the adoption of this procedure.

DISCUSSION.—Scrubbing with a brush, soap and water removes the transient bacterial flora from the skin readily but the resident flora more slowly. Price has shown that in eight minutes of scrubbing the bacterial flora on the hands and arms is reduced about 50 per cent. Although soap and water is not strongly bacterial[4] its usefulness in the treatment of wounds has been proved beyond peradventure, and is due to its efficiency in removing foreign material and bacteria by the scrubbing.[5, 6, 7] However, this is not a factor in our cases. The abdomen was covered with sterile towels after preparation but not in a manner which would exclude bacteria. If there is any effect whatever from the procedure, it is the mechanical trauma to tissue induced by the scrubbing which invites the protective reaction. In this regard, it is possibly comparable to the prophylactic use of vaccines in the peritoneal and joint cavities (bacterial trauma), beef broth in the pleural cavity, tincture of iodine on the skin, or sulfonamide drugs in surgical wounds as a prophylactic measure (chemical trauma). It will be noted from our discussion that experimental and clinical results have not been very conclusive. However, from these observations we may deduce that preliminary scrubbing 24 hours before operation, even with protective coverage of sterile towels, is not effective in the prevention of infection from gross contamination or injury to tissue. Furthermore, it has been shown that bacteria are present in the abdominal wall after meticulous preparation.[8] These residual bacteria will continue to grow after scrubbing and will be present on the next morning in numbers equal to those which have been removed the night before.

One of the most common causes for delayed wound healing is infection. It is, also, a threat to the life of the patient who has been operated upon. Perhaps we have been concentrating too much on the activities of the invading organism and its exclusion or annihilation rather than the resistance of body tissue to these organisms.[9] Even in clean wounds made under so-called aseptic conditions, bacteria are present.[7] Since their complete exclusion is impossible under the most favorable conditions, it behooves us to study nature's power to combat the invasion of micro-organisms. The mere presence of bacteria (contamination) does not constitute an infection. Only if they invade, multiply, and destroy cells, are they of importance. Two factors must be considered: First, the invading organism; and, second, the ability of the tissue to prevent their growth. In the latter may be included trauma to tissue which lowers resistance along with such factors as provide a high degree of immunity in certain areas. This study does not question

the necessity for immediate preoperative preparation of the abdominal wall, nor the type of preparation which may be employed, nor does it imply that any of the aseptic precautions of modern surgery be relaxed. Our study shows that scrubbing the abdomen for eight minutes 24 hours before surgery with soap and water in the experimental animal or in the human patient, apparently does not increase the local resistance of tissue, or eliminate the invading organism sufficiently to prevent infection in surgical wounds in the presence of gross contamination. If carried out 96 to 120 hours before surgery it is, perhaps, useful in increasing local tissue resistance, although there is no direct proof of this. In the presence of gross contamination it is better to close the skin and subcutaneous tissue with a wide gap, as we have always done, or to leave it open entirely, as recently advocated by Coller and Volk.[10]

In all grossly contaminated surgical wounds there must be provision for drainage. This should be made without resort to drains which act as a foreign body and predispose to infection.

A clinical study of so few cases is not conclusive. However, this is a preliminary report, written with the hope that others may help the author to properly evaluate the procedure.

CONCLUSIONS

1. The use of preoperative surgical scrubbing of the abdomen in patients with fecal fistula does not interfere with wound healing when employed 96 to 120 hours before surgery.

2. It probably affords some increase in local immunity due to the stimulation of the blood supply. But it must never be relied upon to prevent infection in the presence of gross contamination. In such cases there must be provision for skin and subcutaneous drainage by very loose closure and no drainage tubes.

3. Scrubbing 12–24 hours before surgery has no demonstrable effect on local immunity.

REFERENCES

[1] Berman, J. K., Sage, Charles, and Ballenger, Felix: Chronic Idiopathic Ulcerative Colitis Treated by Total Colectomy. Quart. Bul. Ind. Univ. Med. Center, **4**, 77–81, July, 1942.

[2] Price, P. B.: Bacteriology of Normal Skin: A New Quantitative Test Applied to a Study of the Bacterial Flora and the Disinfectant Action of Mechanical Cleansing. J. of Infec. Dis., **63**, 301–318, 1938.

[3] Price, P. B.: Ethyl Alcohol as a Germicide. Arch. of Surg., **38**, 528, March, 1939.

[4] Lane, C. Guy, and Blank, Irvin H.: Cutaneous Detergents. J. A. M. A., **118**, 804, March 7, 1942.

[5] Koch, S. L., and Mason, M. L.: Division of the Nerves and Tendons of the Hand. S. G. & O., **56**, 1–39, 1933.

[6] Reid, M. R., and Carter, B. N.: The Treatment of Fresh Traumatic Wounds. ANNALS OF SURGERY, **114**, 4–18, 1941.

[7]Berman, J. K.: Synopsis of Principles of Surgery. C. V. Mosby Co., p. 24, 47 and 278, *etc.*

[8] Ives, H. R., and Hirschfeld, J. W.: Bacterial Flora of Clean Surgical Wounds. ANNALS OF SURGERY, **107**, 607, 1938.

[9] Berman, J. K.: Critical Evaluation and Present Status of the Theory of Focal Infection. J. Ind. State Med. Assoc., **21**, 665, December, 1931.

[10] Coller, F. A., and Volk, W. L.: The Delayed Closure of Contaminated Wounds: A Preliminary Report. ANNALS OF SURGERY, **112**, 256–270, August, 1940.

[11] Berman, J. K., Houser, Alan D., and Kurtz, Wm. A.: Preoperative Scrubbing in Abdominal Surgery: I—Experimental Studies. ANNALS OF SURGERY, **117**, 535–543. April, 1943.

CLINICAL USES OF VITALLIUM

CHARLES S. VENABLE, M.D., AND WALTER G. STUCK, M.D.

SAN ANTONIO, TEXAS

SINCE PIONEER SURGEONS began to contrive operations of various types, there has been a keen interest in the use of metallic appliances to aid in supporting tissues. Metal cleft palate plates, bone plates, screws, wire, skull replacements, intestinal anastomosis tubes, cannulae, and many other metallic contrivances have been devised to aid the surgeons in reconstructing some defect in the body. Scores of implements made of nearly every known

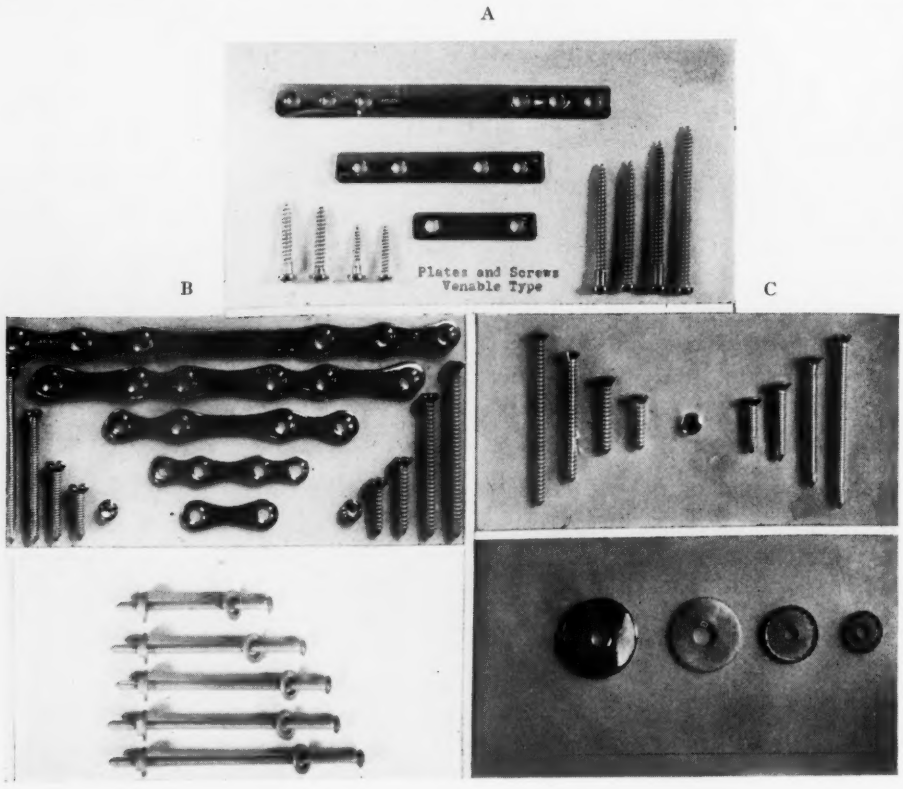


FIG. 1.—(A) Curved metal plates and flat-headed screws of Vitallium designed by Venable for use in bone surgery. (B) Sherman-type plates and machine screws made of Vitallium. (C) Vitallium screws of the wide thread-type, made with Phillips recessed heads, which provide a much firmer grip for the screwdriver. (D) Vitallium bolts devised by Barr for fractures of the tibial plateau. (E) Vitallium washers, prepared to supplement bolts and screws in the fixation of fractures.

metal have been conceived and utilized at one time or another. Nevertheless, in spite of this long search for suitable metal devices for use in surgery, there was slight success and metals came to be discarded because they seemed to be "foreign bodies" that were poorly tolerated by the tissues.

With the introduction of the alloy, Vitallium, into bone surgery in 1936,

we were able to present a metal which was inert in the body fluids and consequently free of any unfavorable tissue reactions. Moreover, we were able to establish the principle that no metal is suitable in the body if it is subject to corrosive change due to chemical or electrolytic action in the tissue

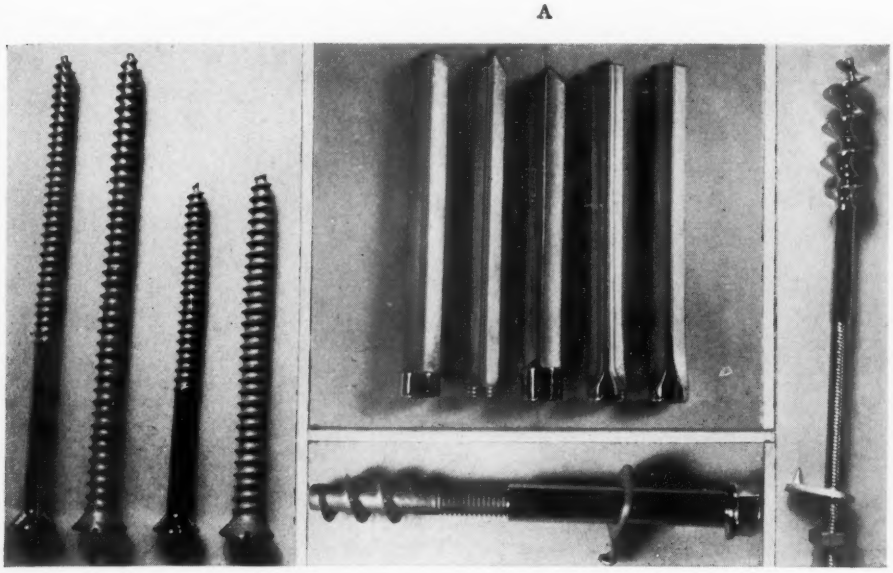


FIG. 2.—(A) Vitallium Smith-Petersen hip nails with various types of head and tips. (B) Venable-type Vitallium hip screws for fractures of the hip, tibial plateau or condyles of the femur. (C) Henderson lag-screw of Vitallium for fractures of the neck of the femur. (D) Lippman cork-screw bolt for hip fractures.

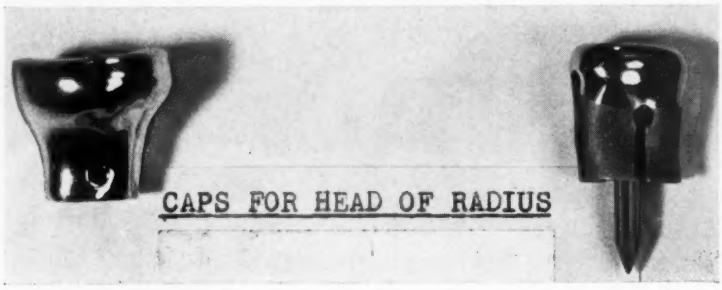


FIG. 3.—Kellogg Speed's Vitallium cap for the head of the radius.

fluids. The recognition of the results of electrolytic action between metals in the body as a cause of failure of metal appliances was a concept which had been suggested previously by others, but discarded by them since it was not clearly understood that corrosion is dependent upon electrolytic action. That electrolytic action accompanied unfavorable tissue reaction, we found to be uniformly true and the elimination of electrolytic action through use of

a metal which resisted chemical effects of body fluids eliminated the usual damage. Our first animal experiments on electrolysis of metals in the body were undertaken in 1935–36, wherein we came upon Vitallium, a dental alloy, which had been developed by the Austenal Laboratories because of its entire corrosive resistance to saliva. After demonstrating that Vitallium was inert or passive in the body fluids of animals, we had plates and screws made to use in human bones. The first clinical case was operated upon in

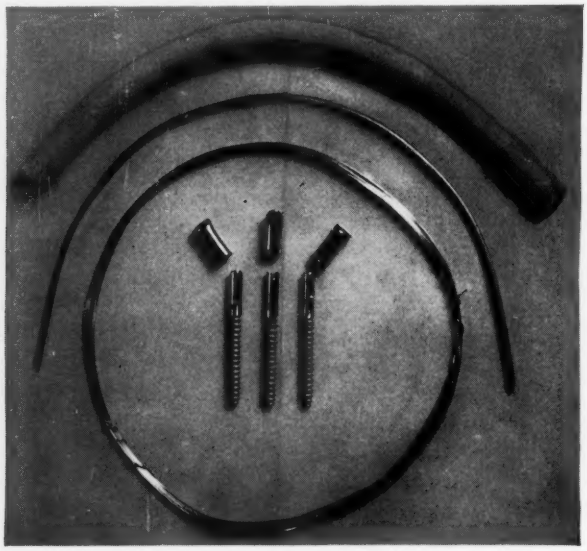


FIG. 4.—Berry's Vitallium screws for fractures of the mandible.

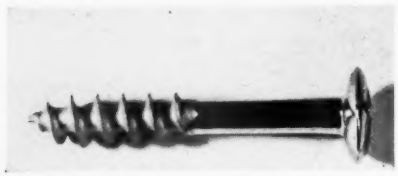


FIG. 5.—Bosworth's Vitallium coracoclavicular screw.

September, 1936, and since that time hundreds of operations have been performed by many surgeons in which Vitallium appliances have been used. After six years' experience in hundreds of cases, it is now well established that Vitallium is the most inert alloy currently used in surgery. As this record has become known, Vitallium appliances of diverse types have been designed by surgeons in other fields than orthopedic surgery. It is this development which we wish to report to demonstrate the protean utility of

this alloy and its complete tolerance to the various fluids and secretions of the body because of its chemical and electrolytic inertness.

FRACTURES

In traumatic surgery, bolts, screws, and plates of Vitallium have been found to be most useful in repairing fractures which could not be maintained in position by wires, kangaroo tendon, beef bone screws, or other less stable

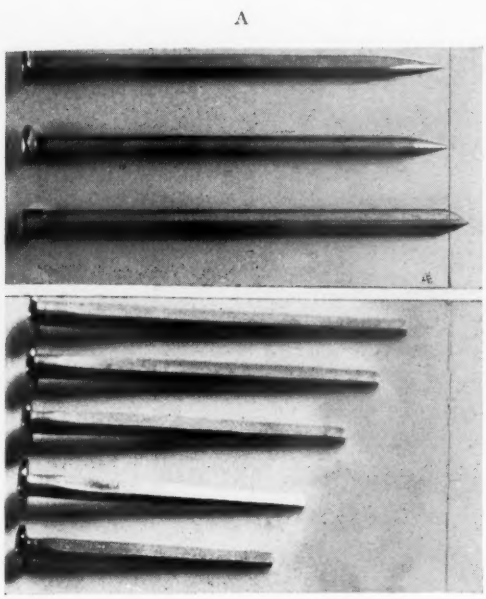


FIG. 6.—(A) Venable-Stuck square nails of Vitallium for arthrodesing joints and to secure condylar fragments in fractures. (B) Vitallium Smith-Petersen arthrodesis pins to stabilize joints after fusion operations.

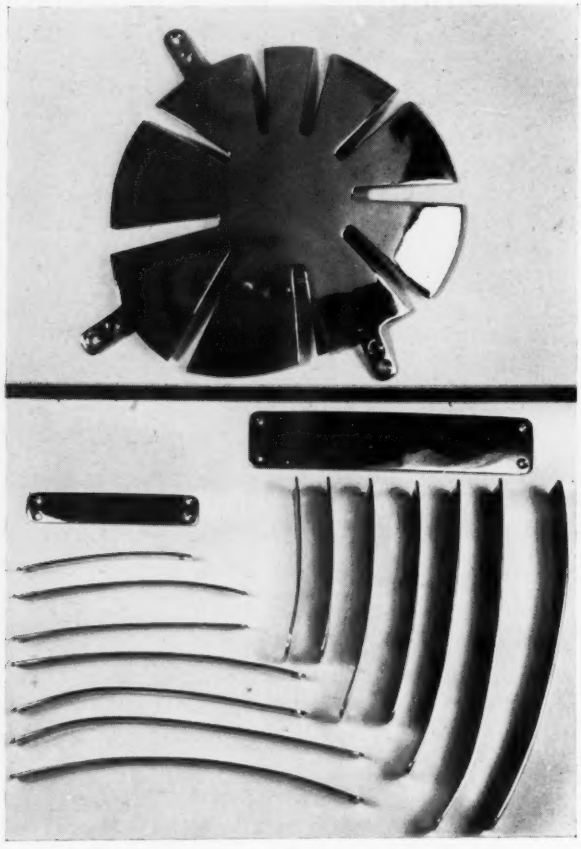
FIG. 7.—Vitallium replacement of the upper end of the femur, devised by Bohlman and Moore and used after resection for a malignant tumor.

materials. Fractures of long bones, intercondylar fractures into joints, and certain grossly displaced fractures, when replaced and anchored by Vitallium screws and plates have been found to heal more rapidly and with less disability than if treated by appliances of other metals (Fig. 1).

The special problem of fracture of the hip has been nearly solved in recent years by the use of nails, screws, or pins to fasten the head fragment to the neck. This has lead to a much greater prospect of union of the fractures, has eliminated the need for hip spica encasements, has prevented

stiffness of the knee, and has generally given the victims much more comfort and hope of ultimate recovery. These large hip nails and screws often came loose or had to be removed because of unfavorable reactions about them. However, since they have been made of Vitallium, irritation of tissue has been eliminated and the need for the second operation of removal markedly diminished (Fig. 2).

A



B

FIG. 8.—(A) Geib-type Vitallium skull plate for the repair of cranial defects. (B) Vitallium strips devised by Claude Beck to cover defects in the skull.

After removal of the head of the radius for comminuted fracture or in arthroplasties of the elbow, a Vitallium radial cap, designed by Kellogg Speed, has been found to facilitate motion and prevent excess new bone formation (Fig. 3).

In fractures of the jaw, Berry has devised Vitallium screws which are anchored in the fragments to support them in the correct position during healing and to prevent displacement (Fig. 4).

For acromioclavicular separations where the ligaments are severely lacerated, Bosworth's screw of Vitallium has been found to be useful in fastening the end of the clavicle to the scapula (Fig. 5).

For the reattachment of small fracture fragments or to anchor joints after arthrodesing operations, several types of round, square, and flanged nails of Vitallium have been devised to aid in the operation (Fig. 6).

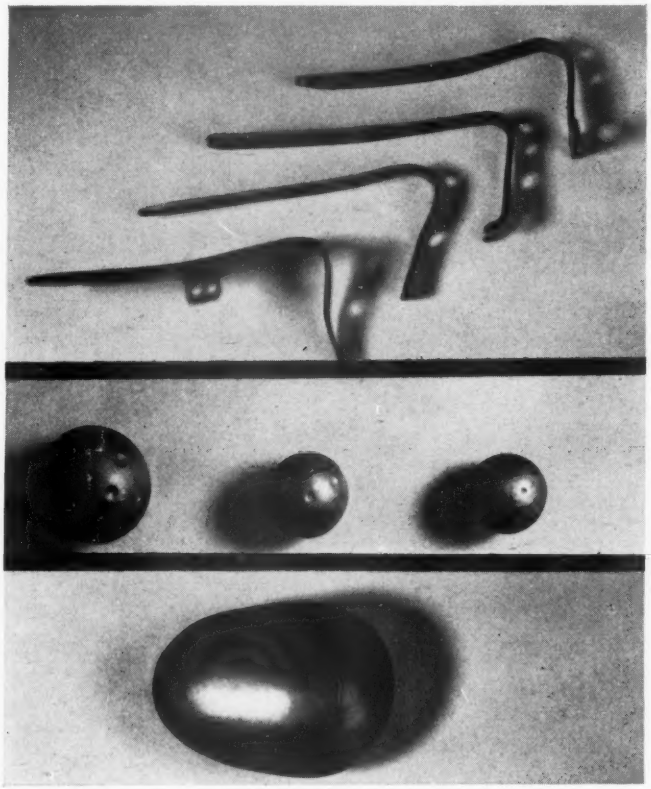


FIG. 9.

FIG. 10.

FIG. 11.

FIG. 9.—Kimball's Vitallium nasal skeletal supports for the repair of "saddle nose" deformity.
FIG. 10.—Doherty's Vitallium orbital implants.
FIG. 11.—Bowers' Vitallium testicle replacement.

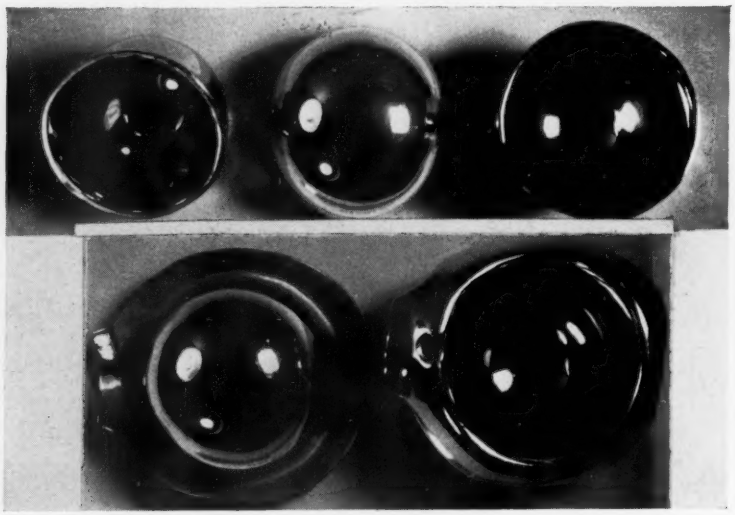
TISSUE REPLACEMENT

The most spectacular use of a Vitallium appliance to replace lost tissue was Bohlman and Moore's metal head and neck of the femur. After the entire upper end of the femur had been resected for a malignant tumor, a Vitallium replacement was inserted which functioned normally. The patient was thereby given a strong, stable, painless hip on which he walked for several years (Fig. 7).

For defects of the skull, Vitallium plates serve as dependable, comfortable protectors of the adjacent soft tissues without the usual headaches (to surgeon

and patient) and irritation that follow most other replacements. Geib devised a plate which was modeled to fit the defect under consideration, while Claude Beck developed various sizes of Vitallium strips which could be used without preliminary preparation (Fig. 8).

A



B

FIG. 12.—(A) Smith-Petersen Vitallium hip caps for repair of ankylosed joints or those in which there has been much destruction of the joint surface. (B) Albee-Preston Vitallium hip sockets for arthroplasty of the hip.

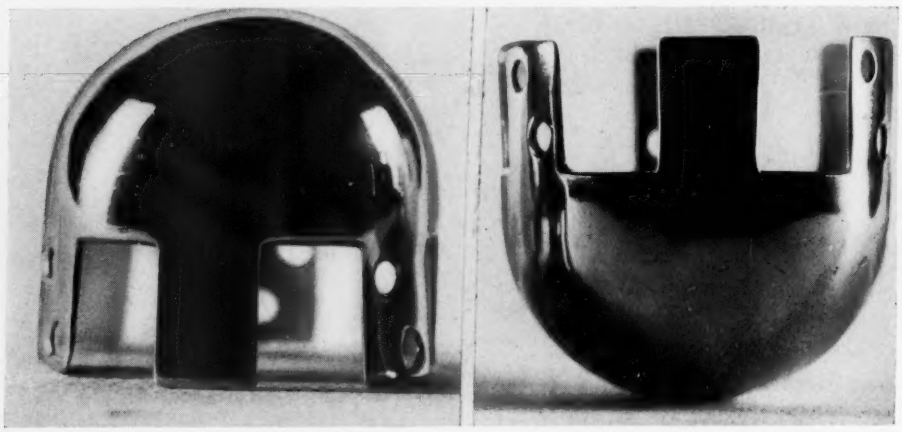


FIG. 12(C).—Venable-type hip cap which is secured by flanges and screws to the neck of the femur.

The bridge of the nose often loses its bony support after osteomyelitis or congenital lues, which results in the classical "saddle nose" deformity. During plastic operations to repair the defect, a Vitallium support has been

used to restore the normal contour while holding the external skin in position (Fig. 9).

After enucleation of the eye, some implant is needed to preserve the skin folds and provide a foundation for an artificial eye. Many materials have been utilized, though Doherty feels that the Vitallium replacement is more comfortable and secure than any of the previous appliances (Fig. 10).

FIG. 13.

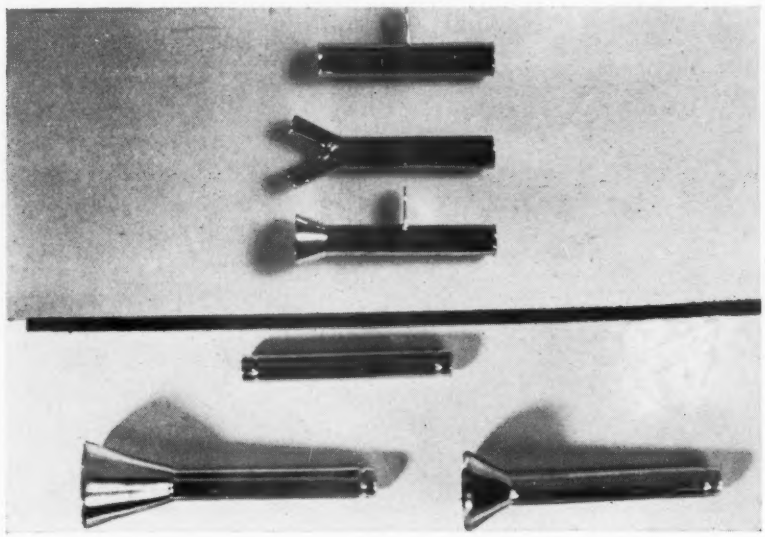


FIG. 14.

FIG. 13.—Pearse Vitallium tubes for repair of the bile ducts.
FIG. 14.—Lord's Vitallium tubes for repair of strictures of the ureter.

FIG. 15.—Smith's colostomy plug of Vitallium to be worn externally over a colostomy stoma.

When the testicle is removed for any reason, it is desirable to replace the defect to overcome unsatisfactory psychologic reactions. Vitallium implants have been found most satisfactory since they are light in weight and nonirritating, though patients notice that they are cold (Fig. 11).

ARTHROPLASTY OF JOINTS

The problem of restoring motion to ankylosed joints has occupied the attention of surgeons for many years. Pieces of fascia lata, pig bladder, and fat, have been used with varying degrees of success as an interposing material. Since the introduction of Vitallium, metal appliances have been used to line the hip, knee, elbow, and finger joints. The most successful of these metal joints is the hip, because this joint is more simple mechanically and is better suited to such reconstructive procedures. Venable devised a fixed type of Vitallium hip cap, while Smith-Petersen has advocated the free floating type (Fig. 12).

BILE DUCT TUBES

Pearse and Clute have devised Vitallium tubes to place in the bile ducts for the repair of strictures or to replace irreparable damage to the ducts. This is the first material which has been found that will resist the action of bile and still cause no irritation to the adjacent soft tissues. The success of these bile tubes has opened new vistas in the surgical replacement or repair of damaged digestive or excretory organs (Fig 13).

URETER TUBES

The problem or repairing or replacing portions of a ureter requires that a tube will maintain its normal lumen without any incrustation and be free of any other irritative phenomena. Vitallium tubes have been used successfully for this purpose as well as for the maintenance of permanent suprapubic cystotomies (Fig. 14).

COLOSTOMY PLUG

While a colostomy plug is not an application of metal within the body, still, it necessitates a material which will resist the intestinal contents and at the same time rest against the abdominal wall without causing irritation of the skin. Smith's colostomy plug of Vitallium seems to meet all these requirements and to be far superior to any other materials which have been used heretofore (Fig. 15).

SUMMARY

It has been more than six years since we demonstrated the effects of electrolysis of metals in the body and introduced the inert alloy, Vitallium, into surgery. During this time, many uses have been found for Vitallium where a passive metal appliance was desired. While there are numerous devices which have been made of Vitallium that have not yet been reported by their sponsors, we are presenting some of those which are better known to show the wide range of usefulness of this metal. In many of these locations, no metal has previously been available which could be used with success because of harmful electrolytic effects.

BIBLIOGRAPHY

1 Albee, F.: A New Vitallium Cup for Athroplasty of the Hip. Jour. Internat. Coll. of Surg., **4,** 289–293, 1941.

2 Barr, J. S.: Treatment of Fractures of External Tibial Condyle. J. A. M. A., **115,** 1683–1687, 1940.

3 Berry, H. C.: A New Departure from Orthodox Methods of Setting Fractured Edentulous Mandibles. Jour. Amer. Dental Assn., **28,** 388–392, 1941.

4 Bigelow, H. M.: The Treatment of Fractures of the Mandible with Vitallium Screws. Med. Bull. Vet. Adm., **17,** 54–56, 1940.

5 Bosworth, B. M.: Acromioclavicular Separations. Surg. Gynec. & Obst., **72,** 667–669, 1941.

6 Burman, M. S.: Vitallium Cap Arthroplasty of Metacarpophalangeal and Interphalangeal Joints of the Fingers. Bull. Hosp. for Joint Dis., **1,** 79–89, 1940.

7 Campbell, W. C., and Speed, J. S.: The Use of Vitallium as a Material for Internal Fixation of Fractures. ANNALS OF SURGERY, **110,** 119, 1939.

8 Campbell, W. C.: Interposition of Vitallium Plates in Arthroplasties of the Knee. Amer. Jour. Surg., **47,** 639–641, 1940.

9 Campbell, W. C., and Boyd, H. B.: Fixation of Onlay Bone Grafts by Means of Vitallium Screws in the Treatment of Ununited Fractures. Amer. Jour. Surg., **51,** 748–756, 1941.

10 Clute, H. M.: Bile Duct Reconstruction With Vitallium Tubes. New England Jour. Med., **226,** 484–487, 1942.

11 Doherty, W. B.: A New Implantation Sphere Made of Vitallium. Arch. Ophthal., **22,** 337–338, 1939; *idem:* Orbital Implants: With Special Reference to Vitallium. Arch. Ophthal., **25,** 637–642, 1941.

12 Geib, F. W.: Vitallium Skull Plates. J. A. M. A., **117,** 8–12, 1941.

13 Girsdansky, J., and Newman, H. F.: The Use of A Vitallium Testicular Implant. Amer. Jour. of Surg., **53,** 514, 1941.

14 Hopkins, H. H., and Zuck, F. N.: Arthroplasty of Hip With Use of Vitallium Cup. Med. Bull. Vet. Adm., **15,** 1–2, 1938.

15 Jewett, E.: One-Piece Angle Nail for Trochanteric Fractures. Jour. Bone and Joint Surg., **23,** 803–810, 1941.

16 Kimball, G. H., and Drummond, R. N.: Vitallium for Nasal Skeleton Support. Jour. Okla. Med. Assn., **34,** 9–13, 1941.

17 Logsdon, C. M.: Utilization of Vitallium Appliances to Treat Edentulous Mandible Fractures. Jour. Amer. Dental Assn., **29,** 970–978, 1942.

18 Lord, J. W., and Eckel, J. H.: The Use of Vitallium Ureter Tubes. Jour. Urol., (In press)

19 O'Donoghue, A.: The Phillips Recessed Head Screws. Amer. Jour. of Surg., **54,** 758, 1941.

20 Pearse, H. E.: Benign Stricture of the Bile Duct Treated with a Vitallium Tube. Surgery, **10,** 37–44, 1941; *idem:* Vitallium Tubes in Biliary Surgery. ANNALS OF SURGERY, **115,** 1031, 1042, 1942.

21 Secord, E. W., and Breck, L. W.: A Case in which a Vitallium Plate Could Not Be Removed. Jour. Bone and Joint Surg., **22,** 749, 1940.

22 Smith, T. E.: Controlling Colostomies. Texas State Jour. of Med., **37,** 241–245, 1941.

23 Smith-Petersen, M. N.: Arthroplasty of The Hip: A New Method. Jour. Bone and Joint Surg., **21,** 269–288, 1939.

24 Speed, Kellogg: Hip Arthroplasty with Vitallium Cap. Western Jour. Surg. Gynec. & Obst., **48,** 101–105, 1940; *idem:* Ferrule Caps for Head of Radius. Surg., Gynec. & Obst., **73,** 845–850, 1941.

25 Strock, A. E.: Experimental Work on a Method for the Replacement of Missing

Teeth by Direct Implantation of a Metal Support Into the Alveolus. Amer. Jour. Orthodontics & Oral Surgery, **25,** 467–472, 1939.

[26] Stuart, F. A.: The Use of Vitallium Screws in Fractures of the Long Bones. Jour. Okla. Med. Assn., **33,** 8–11, 1940.

[27] Stuck, W. G.: Electrolytic Destruction of Bone Caused by Metal Fixation Devices. Jour. Bone and Joint Surg., **35,** N. S. No. 19, 1077–1080, 1937.

[28] Tuell, J. I.: Vitallium in Internal Fixation in Bone Surgery. Northwest Med., **39,** 163–165, 1940.

[29] Venable, C. S., Stuck, W. G., and Beach, A.: The Effects on Bone of the Presence of Metals: Based Upon Electrolysis. ANNALS OF SURGERY, **105,** 917–938, 1937.

[30] Venable, C. S., and Stuck, W. G.: Electrolysis Controlling Factor in the Use of Metals in Treating Fractures. J. A. M. A., **111,** 1349–1352, 1938; *idem:* Recent Advances in Fracture Treatment with Nonelectrolytic Metal Appliances. Jour. Ind. Med. Assn., **31,** 335–342, 1938; *idem:* Vitallium Nails in Fracture of the Hip. Surg., Gynec. and Obst., **70,** 964–968, 1940; *idem:* The Use of Vitallium Appliances in Compound Fractures. Amer. Jour. Surg., **51,** 757–766, 1941; *idem:* Three Years' Experience With Vitallium in Bone Surgery. ANNALS OF SURGERY, **114,** 309–315, 1941; *idem:* A General Consideration of Metals for Buried Appliances in Surgery. Surg., Gynec. and Obst., **76,** 297–304, 1943.

BRIEF COMMUNICATIONS

TRANSPLANTATION OF THE PERITONEUM DURING SUPRAPUBIC CYSTOTOMY

ROBERT L. PAYNE, M.D.
NORFOLK, VIRGINIA

SUPRAPUBIC CYSTOTOMY is both an urgent and necessary procedure under many conditions. A second suprapubic cystotomy following a previous one is also a frequent necessity. It is during the effort to perform a secondary

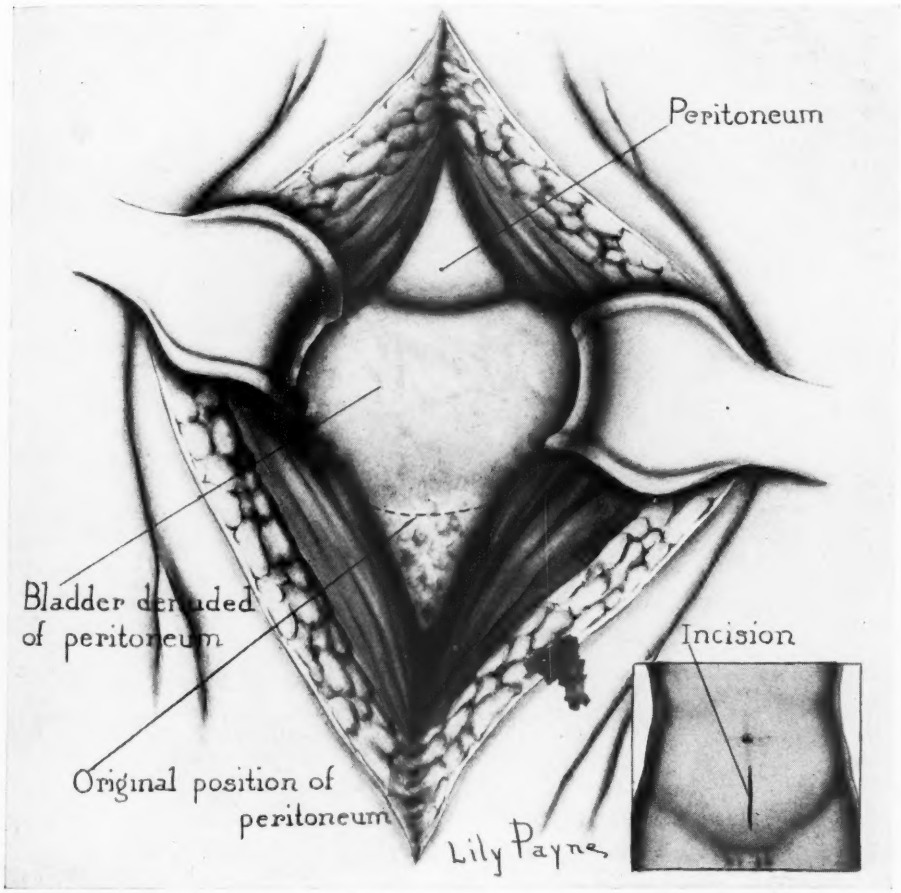


FIG. 1.—Dotted line represents anatomic position of peritoneum. Drawing shows peritoneum has been dissected upward from anterior surface of bladder to highest point possible on dome.

suprapubic cystotomy that the peritoneum over the bladder is frequently opened, due to the adhesive confluence of the layers of the abdominal wall. Following the first suprapubic cystotomy, if the peritoneum is opened, usually dirty, infected urine from the bladder is extravasated into the peri-

toneal cavity, which, in many instances, results in the serious complications of peritonitis. Frequently a small rent is made at the time of the second suprapubic opening of the bladder without the knowledge of the surgeon, and rather large amounts of infected urine escape into the peritoneal cavity.

To prevent this complication of peritoneal contamination by urine, I have been transplanting the peritoneum, as a routine, in every primary supra-

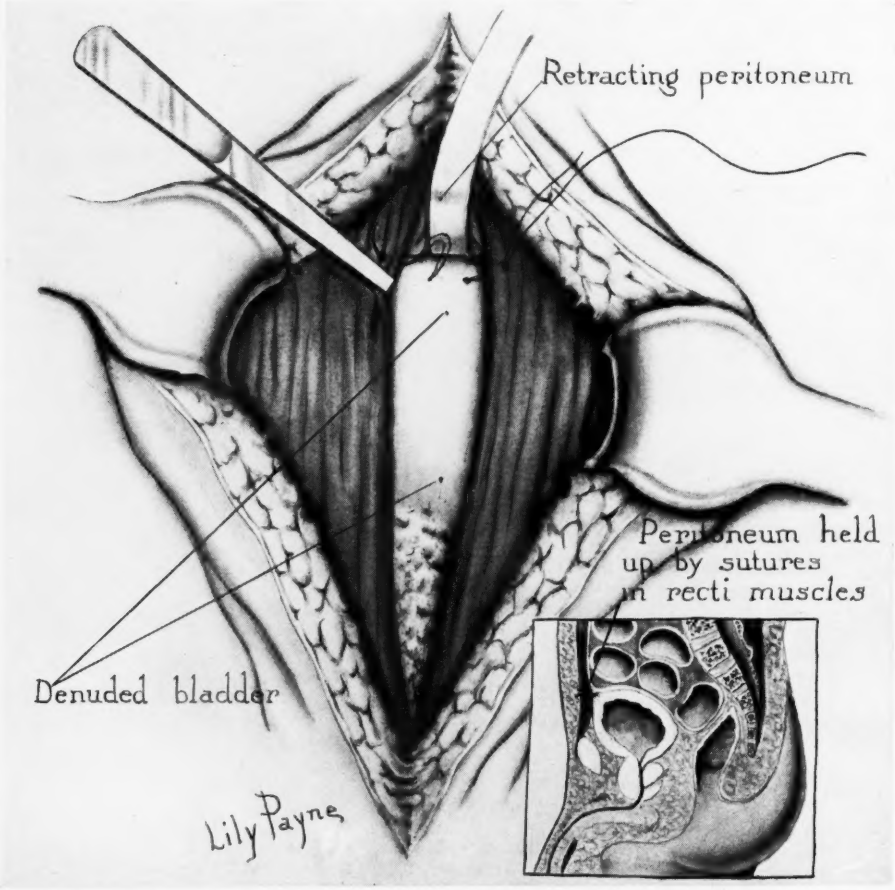


FIG. 2.—Peritoneum fixed in position of high transplantation by one or more sutures placed through rectus sheath and bladder wall.

pubic cystotomy for the past 25 years. I have experienced a great deal of satisfaction and comfort from the procedure herein described of permanently transplanting the peritoneum high up and well back on the dome of the bladder, thus eliminating the possibility of tearing into the peritoneum when opening the bladder again, following a previous suprapubic cystotomy. The illustrations show that the first step, after the bladder is exposed, is to strip the peritoneal reflexion, over the bladder, upward as high as possible, and maintaining the peritoneum in this transplanted position by suturing the rectus fascia and sheath to the bladder at the highest point in the wound.

This not only provides a wide area of the anterior surface of the bladder, through which the opening in the bladder is made, but also prevents the peritoneal reflexion from subsequently rolling downward and becoming adherent in the lower region of the incisional approach to the bladder. Thus, in doing any subsequent suprapubic cystotomy, the danger of opening the peritoneum is eliminated, and one can approach the bladder at the secondary cystotomy through the old incision and through the anterior bladder wall with confidence against peritoneal contamination by infected urine. Over a period of years, I have observed a few fatal instances of peritonitis due to urinary extravasation into the peritoneal cavity following a secondary suprapubic cystotomy. It is often necessary to open the bladder a second time by suprapubic approach for recurring tumors, incompletely removed, solitary ulcers, recurring stones, diverticula, and last, but not least, the day has not passed when suprapubic prostatectomy in two stages may be the method of choice for hypertrophy of the prostate.

The procedure herein described is probably being utilized by many surgeons, and I know of a good many who have adopted this procedure after it was demonstrated to them by me. Since I have never seen this maneuver described in literature, I am submitting it for what possible good may accrue therefrom.

TRANSVERSE MEGACOLON ASSOCIATED WITH CHRONIC VOLVULUS

CASE REPORT

LOUIS P. RIVER, MAJOR, M. C.
FORT WORTH, TEXAS
AND
JOHN A. GUBLER, LT., M. C., U.S.N.R.
NORFOLK, VIRGINIA
FROM THE DEPARTMENT OF SURGERY, LOYOLA UNIVERSITY COLLEGE OF MEDICINE, AND THE COOK COUNTY HOSPITAL, CHICAGO, ILL.

FEW CASES of congenital or adult megacolon limited to the transverse colon have been reported.[1] We have been unable to find recorded in the literature any case of chronic volvulus of such a megacolon. Striking parallelism exists, as might be expected, between the history, symptoms and findings in the case herewith presented and similar lesions of the cecum and sigmoid.

In a communication on volvulus of the cecum, River and Reed[2] described recurrent obstructive episodes, characterized by slow progress, diffuse colic and tenderness, marked tolerance by the patient to the incomplete obstruction and great distention, and late vascular damage. Similar observations have been made regarding recurrent or chronic volvulus of the sigmoid, almost habitually associated with megacolon of that segment.[3, 4, 5] In both diseases the dilatation and hypertrophy of the involved segment is evidence of a long-continued physiologic maladjustment, of which extrinsic causes such as cathartic habituation must be distinctly secondary. Anatomic variations such as hypo- and hyperfixation provide the opportunity for kinking. Obviously, it is impossible from this case to adduce evidence for other possible intrinsic etiologic factors, or to say whether the elongated thickened mesocolon or the heavy, hypertrophied transverse colon was primary. No organic obstruction was found at the splenic flexure.

The enormous abdominal distention and respiratory distress seen in our patient agree with the conditions present in sigmoid volvulus. The radiation of pain into the right flank was probably because of pull on the parietal peritoneum at the hepatic flexure and distention of the proximal ascending colon. The pain in the right shoulder and down the arm was apparently the result of diaphragmatic irritation from the enormous pneumoperitoneum due to intermittent leakage through multiple small perforations. We are unable to explain how this happened without gross peritoneal contamination. About nine months elapsed between the first and second attacks observed by us, although the patient said that he had had them as often as once a month.

Case Report.—J. V., white, male, age 58, a street car motorman, was admitted to Cook County Hospital at 10:35 A.M., July 21, 1941, with a diagnosis of acute intestinal obstruction. He complained of abdominal pain and distention beginning 18 hours previously, but stated he had had intermittent attacks of cramping pain at progressively

shorter intervals for ten years, in which epigastric colicky pain radiated to the right flank, constipation was marked, but nausea or vomiting did not occur. With frequent attacks during the past few months he had noted acute, steady pain radiating to his right shoulder and arm. The onset of the present episode was sudden, violent, with severe steady pain in the upper abdomen, mild nausea, but no vomiting. He was

FIG. 1.—Appearance on admission, July 21, 1941

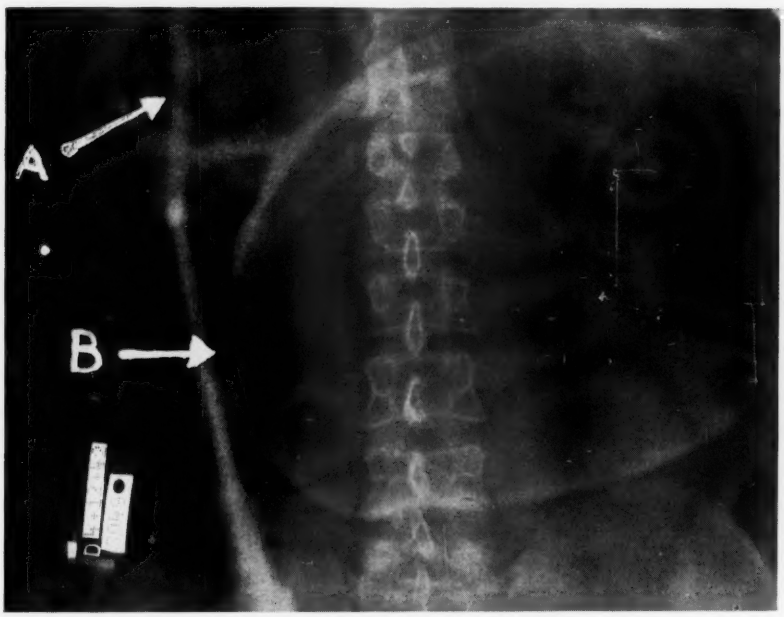


FIG. 2.—Roentgenologic appearance preoperatively, April 12, 1942. A. Distention in proximal bowel. B. Distended megacolon.

taken home, spent the night in great discomfort, occasionally passing flatus, without relief. A large soft bowel movement before admission relieved him somewhat, but he began to note more severe shoulder and arm pain. He gave no history of selective dyspepsia, had been jaundiced mildly ten years ago, said he had had dyspnea lately with attacks. He had controlled a mild diabetes by diet for ten years, discovered when he had a tonsillectomy performed.

Physical Examination.—The patient was a large, obese male (240 lbs.), lying quietly in bed, not seeming acutely ill, with a barrel-like emphysematous chest and enormous soft tympanitic distention of the abdomen (Fig. 1). (The apex of the abdomen was 42 cm. above the table). There were inconstant moist râles at both bases posteriorly. The liver was felt three fingersbreadth below the costal margin; there was direct and rebound tenderness in the epigastrium, no rigidity, masses, scars or herniae. There was moderate periumbilical venous dilatation and engorgement of numerous small veins on the abdomen. Tinkling, high-pitched bowel sounds, 5–10 per minute, not coincident with pain, were heard.

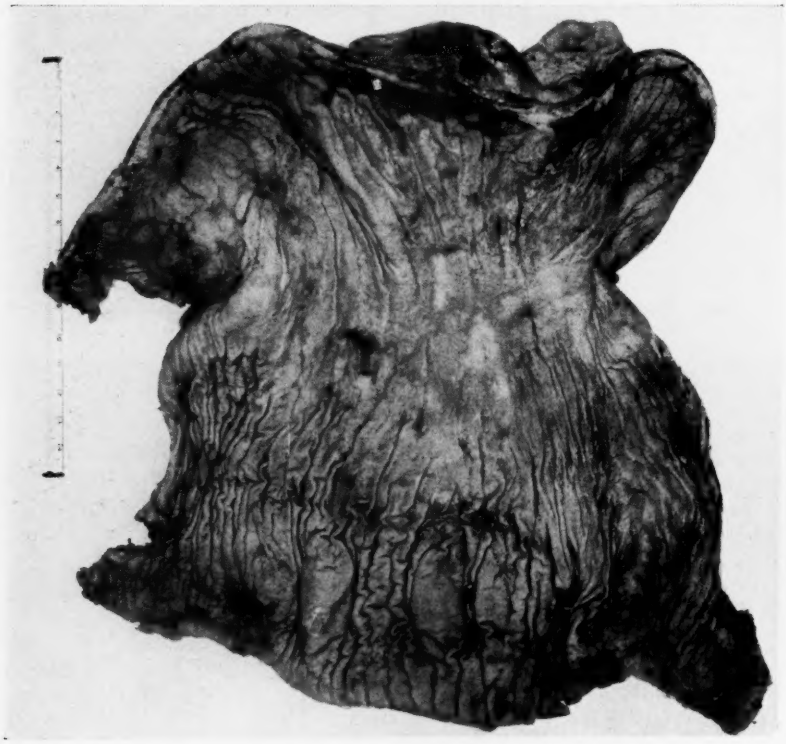


FIG. 3.—Rule is 15 cm. Mucosal aspect. Bowel is opened along mesenteric border in long axis.

The white blood count was 8,500; the urine negative; blood sugar 150 mg. per cent, and icterus index 21. Fifteen hundred cubic centimeters of a two-quart enema were returned highly colored. He was given mineral oil and enemata every two hours. Oil came through in four hours, but the distention became greater. The roentgenologic appearance was almost identical with that seen in Figure 2, and was interpreted by the junior author as volvulus in a Hirschsprung's disease. He continued to pass oil, his tenderness decreased although the distention did not. Seventy-two hours after admission he was given 150 mg. of procaine intrathecally, and passed 5,500 cc. of liquid stool, with large amount of gas. His abdomen flattened out. One week later he left the hospital apparently well.

He was readmitted, April 12, 1942, at 3:55 P.M., six hours after a "normal" bowel movement. He had had increasing distention and diffuse aching pain for three days. The onset had been insidious; dyspnea and right shoulder pain had been severe; he

had no appetite, but had no nausea or vomiting. There was diffuse direct tenderness, extreme tympany. The abdomen was silent. The appearance was the same as before. The roentgenographic appearance, shown in Figure 2, led to a diagnosis of volvulus of the transverse colon. The film was not large enough to show the diaphragmatic region, where the enormous pneumoperitoneum was evident. At 11:20 P.M. he was given 110 mg. of metycaine intrathecally. No evacuation occurred.

Operation.—Through a left paramedian incision, a large amount of odorless air escaped upon incision of the peritoneum. There was an enormous megacolon of the transverse colon, with a 180° counterclockwise volvulus, the proximal portion of bowel (Fig. 2 A) passing behind the distal portion. The wall of the involved colon was thick, leathery and covered with multiple pebbly, verrucous areas, also patches of plastic

FIG. 4.—Appearance after third stage, May 18, 1942.

exudate surrounding minute perforations, through which small qunatities of air escaped on pressure. The loop was untwisted; the mesentery was thick, elongated. Pressure on the loop, with four rectal tubes in place, failed to reduce the tumor appreciably. It was exteriorized, the wound closed and a large catheter purse-stringed into the loop.

During the next ten days bowel sounds became normal, his general condition improved and, on April 24, 1942, the exteriorized mass was resected with the cautery, carefully avoiding damage to mesocolic vessels. The posterior bowel surfaces were sutured leaving a saucer-like defect. Figure 3 shows the resected specimen, opened. The abdomen was scaphoid.

On May 18, 1942 the skin edges were freed, the circumference of the bowel restored by layer closure and the skin closed. No attempt was made to repair the hernia which existed (Fig. 4). There was gradual improvement in the amount of leakage and he was discharged, July 1, 1942, having normal stools, no abdominal pain, and no difficulty from a 4 x 5 cm. hernial defect.

Pathologic Report: A segment of large bowel measuring 27 cm. in length. The wall is 12 mm. thick. The serosal surface is granular, purple-gray and tan. There is marked hypertrophy of muscular elements. The mucosa is gray-tan covered with bloody mucus. In one area are defects one and two millimeters in diameter communicating with the serosal surface. There is a serosal peritonitis.

SUMMARY

1. Associated megacolon and volvulus of the transverse colon is compared with similar lesions of sigmoid and cecum.

2. A case is reported demonstrating the recurrent or chronic character of this previously unreported lesion.

3. The diagnostic importance of plain films of the abdomen is emphasized.

REFERENCES

1 Krombach, K.: Case of Congenital Transverse Megacolon. Monatschrift fur Kinderheilkunde, **38,** 190, Jan.–Feb., 1928.

2 River, Louis., and Reed, Francis A.: Volvulus of the Cecum. ANNALS OF SURGERY, **116,** 874–881, December, 1942.

3 Cope, Zachary: The Early Diagnosis of the Acute Abdomen. Oxford Medical Publications, 6th Ed., 1932.

4 Edwards, Scott R.: Megacolon Associated with Chronic Volvulus of the Sigmoid. Indianapolis Med. Jour., **24,** 139–143, June, 1921.

5 Ligat, D., and Overend, T. D.: Recurrent Volvulus of the Pelvic Colon. Brit. Med. Jour., **3782,** 7–12, July 1, 1933.

ANEURYSM OF THE BRACHIAL ARTERY

REPORT OF SUCCESSFUL ANEURYSMORRAPHY

JOHN P. BRUCKNER, M. D.

NEW YORK, N. Y.

FROM THE SURGICAL SERVICE OF HARLEM HOSPITAL, CLARENCE P. HOWLEY, M.D., DIRECTOR, NEW YORK, N. Y.

TRAUMATIC ANEURYSM of the brachial artery occasionally occurs, and gives rise to disability from enlargement and pressure upon the median and ulnar nerves. Such an aneurysm has arisen as a result of injury to the vessel wall by knife wound, destroying the media but leaving the intima intact. The following case report illustrates the sequence of events occasioned by the gradual enlargement of an aneurysmal sac to the point of producing changes in the nerves to the forearm:

Case Report.—A. L. was admitted to the hospital, May 2, 1942, for a severe knife wound of the midportion of the anterior surface of the right arm. The wound was about five inches long and penetrated the belly of the biceps brachii muscle and injured the outer layers of the brachial artery at the junction of the middle and upper third. Immediate operation consisted of débridement and suture repair of lacerated sutures. The brachial artery was not sutured. Recovery was uneventful, and the patient was discharged on the eighth day postoperative.

On June 29, 1942, he was readmitted for marked swelling in the midportion of the right arm, with sensory disturbances to the forearm, hand and fingers, over the area of the median and ulnar nerve distribution. A diagnosis of aneurysm of the brachial artery following injury was made, and a plan outlined to establish the relationship of the brachial artery and vein to this area. Tourniquets were applied above and below the aneurysm and diodrast injected into the tumor. Roentgenograms were immediately taken. The tourniquets were removed, and two days later a tourniquet was applied to the arm proximal to the aneurysm and diodrast injected into the median basilic vein. Another roentgenogram was taken and compared with that previously taken for evidence of arteriovenous relationship. No arterial and venous communication was noted. However, further study was made to ascertain the carbon dioxide combining power of the venous blood of both forearms. In the specimen from the left forearm the CO_2 combining power was 54 vol. per cent; in that from the right forearm, 52 vol. per cent. From these observations, it seemed logical that the aneurysm involved the brachial artery alone. There was no visible pulsation over the aneurysm and pulsation could not be palpated. The tissues surrounding the aneurysm were very tense, which appeared to account for the absence of pulsation. Auscultation revealed a bruit. Following the injection of diodrast and application of tourniquets the arm rapidly increased in size, apparently from extravasation of blood through the needle puncture wound. The blood Kahn was negative.

Operation.—July 8, 1942: An incision was made over the brachial artery *proximal* to the sac and the brachial artery dissected free from its position between the median and ulnar nerves. A traction tape was applied around the artery for compression when needed. The incision was then enlarged downward over the sac to about 2 cm. distal to the sac and the skin flaps dissected free on either side for a distance of one inch. The sac ruptured spontaneously at this point, expelling bright red arterial blood and a few dark red blood clots. Bleeding was controlled by compression of the artery with the tape pre-

viously applied and by digital pressure over the openings within the sac. A soft rubber, No. 8 F. catheter, coated with vaseline, was inserted into the arterial lumen within the sac. Three layers of Lembert sutures of No. 0 chromic catgut through the walls of the sac, after the manner of Matas' aneurysmorraphy, were applied and the catheter withdrawn. Pulsation of the radial artery at the wrist became full and bounding. The remaining portion of the sac was dissected free and removed. The traction tape surrounding the brachial artery was withdrawn. The deep fascia was closed with continuous catgut sutures and the skin closed with interrupted silk without drainage.

Recovery was uneventful except for a wound infection which was opened on the eighth postoperative day by removal of the sutures. The patient was discharged from the hospital, July 22, 1942, at which time the motor function of the right arm, forearm, and hand was good and the slight sensory loss over the median and ulnar nerve areas previously noted had disappeared.

The patient was again seen, December 18, 1942, and the following notation made: "Function of the forearm, hand and fingers, not restricted. Radial pulsation at the wrist, good. No sensory or motor disturbances found. Wound healed. No evidence of recurrence of aneurysm."

COMMENT.—Aneurysmorraphy, as described by Matas, Bernheim, and others, appeared to offer desirable therapy in this instance since the aneurysm was considered to have been produced following an injury to the arterial wall.

The development of sensory disturbances along the median and ulnar nerves, together with swelling of the hand and fingers resulting from pressure effects upon the return flow of lymph, and the compression of the brachial vein, were indications for operative intervention.

A significant incident of noteworthy interest was the freedom from serious complications that might have been expected from infection in an operative wound of this nature. Aside from induration and swelling of the tissues along the incision, which rapidly subsided with the free outlet of pus, complete recovery and restoration of function was uneventful. Chemotherapy was not employed, and was considered unnecessary, since drainage was adequate.

TRAUMATIC ARTERIOSCLEROTIC ANEURYSM OF THE TIBIAL ARTERY SIMULATING AN OSTEOGENIC SARCOMA OF THE FIBULA

CASE REPORT

JACK D. KIRSHBAUM, M.S., M.D., MAJOR, M.C., AND GEORGE L. KRAFT, M.D., LT. U. S. N.
CHICAGO, ILL.

FROM THE DEPARTMENT OF PATHOLOGY, WOODLAWN HOSPITAL, AND THE ORTHOPEDIC SERVICE OF DR. PHILIP LEWIN, COOK COUNTY HOSPITAL, CHICAGO, ILL.

THE ABILITY of aneurysms of the aorta to erode bone, particularly the vertebra or ribs, is well known, and observed rather frequently. That a traumatic aneurysm of the anterior tibial artery should have assumed such large proportions so as to destroy the upper end of the fibula and clinically manifest itself as a bone sarcoma, is certainly most unusual.

Case Report.—The patient, a white female, age 52, was admitted to the Medical Service, Cook County Hospital, March 22, 1938, with gastro-intestinal complaints. Because of the presence of a large mass in the right leg she was then transferred to the Orthopedic Service. She stated that in February, 1937, she had fallen off a street car. Three months later pain occurred in the lateral aspect of the right leg. The leg

FIG. 1. FIG. 2.

FIG. 1.—Roentgenogram showing beginning erosion in upper third of fibula.
FIG. 2.—Photographs of the aneurysmal mass—simulating a sarcoma.

became red and swollen, and she noticed a small pimple just below the knee. Heat was applied locally for one month. In October, 1938, she was admitted to the South Shore Hospital. A swelling was present in the upper third of the lateral aspect of the right leg. It was excruciatingly tender, and felt fluctuant. The ankles were edematous. A diagnosis of osteomyelitis of the upper third of the tibia, with a subperiostal abscess, was made. Roentgenograms disclosed slight involvement of the periosteum in the upper end of the right fibula (Fig. 1). The tibia was negative. For the past 15 years the

patient had noticed marked dyspnea on exertion and had been told she had heart trouble. No history of rheumatic fever was obtainable. The urine contained much albumin. R.B.C. 3,100,000.

The swelling was incised, and a dark, bloody material was obtained. The swelling reoccurred and nothing was done until she entered the Cook County Hospital in March, 1938. Physical examination disclosed a large fluctuating mass, the size of a grapefruit, in the outer and upper third of the right fibula. The mass was tender, fluctuant in the center and indurated at the periphery. The overlying skin was dis-

FIG. 3.—Roentgenogram showing the large soft-tissue mass and destruction of the upper end of the fibula.

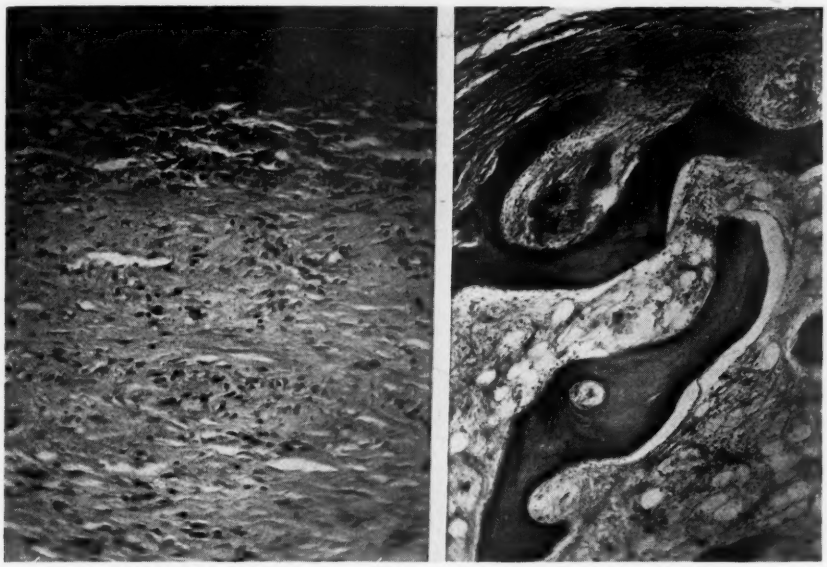
FIG. 4.—Photograph of the excised aneurysm filled with a laminated hematoma.

colored a coppery-brown, which faded towards the periphery, and the central part was covered over by a thick adherent scale. The superficial veins in the skin were very prominent (Fig. 2). Temperature 97.8° F.; pulse 100; respirations 24; blood pressure 126/88. Except for a slight enlargement of the heart, the remaining findings were irrelevant. *Laboratory Data:* Urinalysis showed albumin 2 plus, spr. gr. 1.008, sugar negative. Blood: Hb. 60%; W. B. C. 4,400. Blood Wassermann negative. *Clinical Impression:* Osteolytic sarcoma of the fibula and auricular fibrillation.

Roentgenologic examination of the right leg disclosed complete destruction of the upper end of the fibula and a marked soft-tissue swelling of the upper end of the tibia (Fig. 3).

Subsequent Course: In view of the patients gastro-intestinal complaints, and loss of weight, the lesion in the leg was considered a metastasis. However, roentgenologic studies of the gastro-intestinal tract and chest were all negative. A biopsy taken from the mass disclosed only necrotic tissue. While in the ward the patient developed signs of uremia. Blood chemistry revealed a urea nitrogen of 57.44 mg., and creatinine of 3.74 mg. Although a diagnosis of sarcoma of the fibula was considered, amputation of the leg was thought inadvisable. The condition of the patient became poorer and she expired three months after admission, 15 months following her accident.

Necropsy: The autopsy was restricted to examination of the right lower extremity. The body was that of a fairly well nourished white female. Over the right medial condyle of the femur there was a light purple patch, 20 mm. in diameter. There was a



A B

FIG. 5.—(A) Photomicrograph of the wall of the aneurysmal sac, and, also, (B) of the end of the fibula bone bordering the sac, to exclude the presence of a malignant tumor. Note the dense fibrillar character of the sac and the atrophic spicules of bone.

similar patch over the right patella, and four such patches on the plantar surface of the left foot, the largest, four centimeters, in the region of the heel. There were two other patches, over the right lateral malleolus and on the medial aspect of the heel. The upper two-thirds of the right leg was transformed by a tumor mass, measuring 40 cm. in transverse and 15 cm. in longitudinal diameter. The skin over the lateral aspect of the mass was deeply pigmented and contained a healed scar, four centimeters long. The muscle, in the vicinity of the above described mass, was friable, and in places was replaced by a reddish-brown tissue. On sectioning, the mass was found to be composed of an organized and laminated blood clot (Fig. 4). The inner lining of the sac was fairly smooth and discolored purple-grey. The fibula in the upper third was missing. The end of the bone was roughened and sharply demarcated from the sac. Bordering the sac it was noted to communicate with the anterior tibial artery.

Pathologic Examination.—Microscopic: The sac is lined by a thick layer of red blood cells and fibrin, which rests upon a thick, slightly vascular granulation tissue infiltrated with plasma cells, round cells and an occasional multinucleated giant cell (Fig. 5). There are large numbers of histocytes filled with golden-brown pigment. The wall of the sac, in places, also shows calcification. Bordering this sac there is a large branch of the anterior tibial artery showing a marked calcification of the media,

thickening of the intima, and the lumen partially filled by a recent blood clot. The adventitia is heavily surrounded by large numbers of polymorphonuclear leukocytes, round cells, and eosinophil leukocytes. The elastic stain shows a gap in the wall of the artery and partial replacement by scar tissue, and thus permits free communication between the lumen of the vessel and the aneurysmal sac. In the lumen of the vessel is an organizing small piece of thrombus (Fig. 6). The fibula fragments of bone adjacent to the sac shows widely separated atrophic spicules. The bone marrow is fatty (Fig. 5B). There are no evidences of syphilis or malignancy in the numerous sections taken. *Anatomic Diagnosis:* Arteriosclerotic traumatic aneurysm of the anterior tibial artery and erosion of the upper third of the fibula. Hypertensive heart disease with renal decompensation (clinically) and multiple hemangioma of the skin.

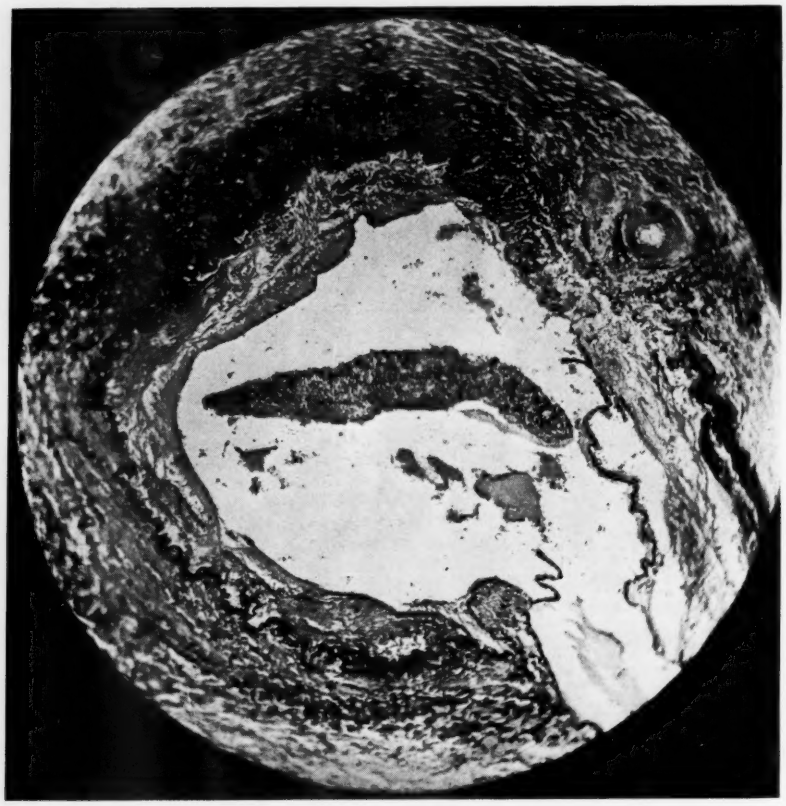


FIG. 6.—Photomicrograph showing the large defect in the wall of the tibial artery. Note the marked sclerosis of the media and the thrombus in the lumen.

Discussion.—There are so-called aneurysms of the bone which are usually located at the ends of the long bones and are called by Ewing[1] telangiectatic sarcomata. These tumors are composed of large vascular spaces and show invasive malignant features. Another type of aneurysm of the bone may be due to the degeneration of a giant cell tumor which permits blood to flow through the large central spaces. These lesions are not aneurysms in the strict sense of the word, since there is not a rupture of the layers of a blood vessel. The true aneurysm shows a rupture in the adventitia, or adventitia

and media layers, permitting a weakening of the wall so that distension occurs and may eventually rupture.

A false aneurysm may result from a traumatic rupture of a vessel wall and the subsequent formation of an encapsulated hematoma communicating with the original vessel (Karsner[2]). The case cited illustrates the formation of a huge aneurysm in an arteriosclerotic blood vessel, following a trauma to the leg, with erosion of the upper end of the fibula bone.

SUMMARY

A case of a false arteriosclerotic traumatic aneurysm of the tibial artery with marked destruction of the fibula bone is here presented.

The aneurysm clinically was mistaken for an osteogenic sarcoma.

REFERENCES

[1] Ewing, James: Neoplastic Diseases. 4th Ed., W. B. Saunders, p. 361, 1940.
[5] Karsner, H. T.: Human Pathology. 5th Ed., J. B. Lippincott Co., p. 902, 1938.

A METHOD OF PROLONGED VENTRICULAR DRAINAGE

ALBERT S. CRAWFORD, M.D.* AND RALPH A. MUNSLOW, M.D.*

DETROIT, MICH.

OCCASIONALLY it becomes necessary to establish ventricular drainage for a number of days or even several weeks. In such cases the greatest risk is of infection. This latter is most likely carried in along the catheter when it has to be manipulated because of stoppage of flow.

FIG. 1.

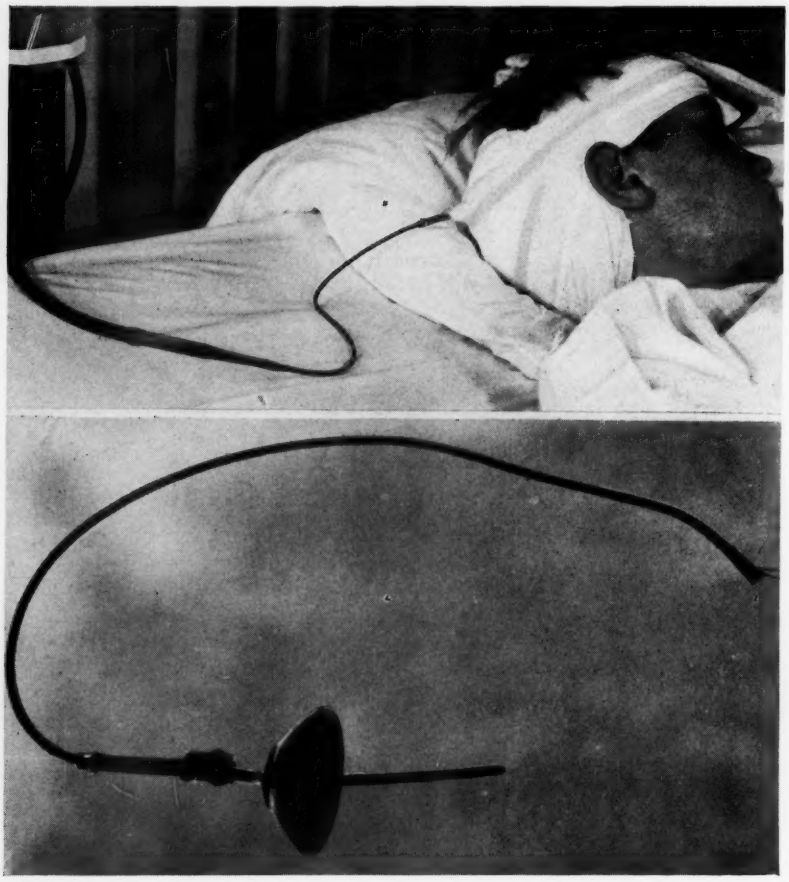


FIG. 2.

FIG. 1.—Shows the apparatus on a boy of 11, with an unremovable midline glioma of the cerebellum. The drainage was continued until the deep X-ray therapy was completed.

FIG. 2.—Shows the catheter and retaining-protecting apparatus assembled. Details are given in the text.

* Albert S. Crawford, Division of Neurologic Surgery, Henry Ford Hospital, Detroit, Mich. Ralph A. Munslow, now Captain U. S. Army Medical Corps.

For a number of years we have used the well known drainage system, pictured here (Fig. 1), which uses an inverted Y-tube to break the suction effect of a column of water. As is known, the resistance to the outflow can be modified by varying the height of the Y-tube above the level of the trephine hole.

The chief difficulty in the method was occasional stoppage of flow, from one cause or another. This problem was solved partly by cutting two or three extra eyes in the inner end of the catheter.

In order to make it somewhat safer against infection, if manipulation of the catheter should become necessary, we added the apparatus herewith pictured (Fig. 2). It consists of an ordinary rubber vacuum cup attached to an enveloping tube by a short glass nipple which has flanges blown at each end. We use a No. 8 French rubber catheter to insert into the ventricle. It can be passed down the pathway made by an ordinary large brain trocar, if the hole in the dura is made slightly larger before the insertion. The enveloping tube is made by cutting off the upper 4.5 or 5 cm. of a size No. 16 F. catheter. The enlarged end slips over the flanged end of the glass nipple. An ordinary Michel clip serves to constrict the outer end of the enveloping tube down, so that it grips the inner catheter snugly. It is safer, however, to also secure it with a piece of thread, fastened on the inner catheter, tied with a clove hitch. The vacuum cup is secured externally to the scalp with three or four silk sutures. If desired, some sulfanilamide, or similar powder, can be used under the rubber cup around the catheter; however, this will cake in a short time. The sterile gauze dressings also help to keep the apparatus in place. Silk ties make all joints of the tubing more secure.

Inasmuch as the whole apparatus is sterilized before assembling, it gives one a closed sterile system which permits, if necessary, of manipulation of the catheter without disturbing the dressings and with less danger of carrying infection inwards with the catheter. One must be sure that the down tube to the collecting bottle is not too long or that it does not become kinked, as there will result a backing up of fluid.

Of course, no method is foolproof. No drainage should be left longer than necessary. We have found this method definitely superior to the other methods we have tried for prolonged ventricular drainage.

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY

Walter Estell Lee, M.D.
1833 Pine Street, Philadelphia, Pa.

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BOOK REVIEW

YEARBOOK OF INDUSTRIAL AND ORTHOPEDIC SURGERY. Edited by Charles F. Painter. M.D. Yearbook Publishers, 424 pp., 302 ills., $3.00, Chicago, 1942.

This compact and well illustrated edition deals almost entirely with orthopedic problems. Most of the articles are well summarized and the operative technic are fully described. The articles on acute hematogenous osteomyelitis emphasize the success of conservative nonoperative therapy using sulfonamides and adequate plaster immobilization. The therapy of chronic arthritis is well represented. Of special interest is the large number of reviews dealing with minor disabling conditions of the shoulder girdle. More than one quarter of the book is given over to fractures and traumatic dislocations—the newest methods of treatment are described and illustrated. The section on industrial medicine and surgery has several reviews dealing with the general problems of industrial health. These are followed by articles discussing specific hazards in the various industries. Taken as a whole the book presents good summaries of the orthopedic and industrial health literature of the past year.

HENRY SALTONSTALL, M.D.

BOOKS RECEIVED

FRACTURES OF THE JAW BONES AND OTHER FACIAL BONES. By Glenn Major, B.S., A.M., Ph.D., D.D.S., M.D. St. Louis: C. V. Mosby Co., 1943.

ENDOSCOPIC PROSTATIC SURGERY. By Roger W. Barnes, M.S., M.D. St. Louis: C. V. Mosby Co., 1943.

OBSTETRICAL PRACTICE. By Alfred C. Beck, M.D. Baltimore: Williams & Wilkins Co., 1942.

THE SIGHT SAVER. By C. J. Gerling, A.B., M.A., B.C. New York: Harvest House, 1943.

THE PRINCIPLES AND PRACTICE OF WAR SURGERY. By J. Trueta, M.D. St. Louis: C. V. Mosby Co., 1943.

OPERATIVE ORAL SURGERY. 2nd Ed. By Leo Winter, D.D.S., M.D. St. Louis: C. V. Mosby Co., 1943.

BEHIND THE SULFA DRUGS. By Iago Gladston, M.D. New York: D. Appleton-Century Company, Inc., 1943.

OPERATING ROOM TECHNIQUES. By Edythe Louise Alexander, R.N. St. Louis: The C. V. Mosby Company, 1943.

ACUTE INFECTIONS OF THE MEDIASTINUM. By Harold Neuhof, M.D., and Edward E. Jemerin, M. D. Baltimore: The Williams & Wilkins Co., 1943.

NURSES IN ACTION. By Colonel Julia O. Flikke, A.N.C., A.U.S. Philadelphia: J. B. Lippincott Company, 1943.

DOCTOR IN THE MAKING. By Arthur W. Ham, M.B., and M. D. Salter, M.A., Ph.D. Philadelphia: J. B. Lippincott Company, 1943.

ANNOUNCEMENT

Announcement is made by the American Urologic Association that the annual prize of $500 will not be awarded this year. Because of government restrictions on the holding of medical conventions except those primarily of military interest, the meeting of the American Urologic Association, which was to have been held in St. Louis, is cancelled.—Committee on Research, American Urologic Society.